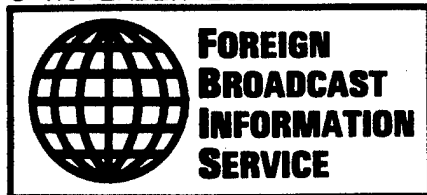


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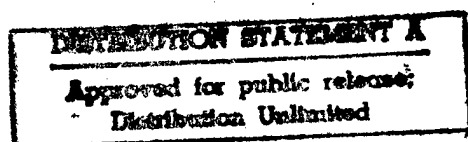
9 NOVEMBER 1987



# ***JPRS Report***

# **Science & Technology**

***USSR: Materials Science***



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## SCIENCE & TECHNOLOGY

### USSR: MATERIALS SCIENCE

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UDC 621.74:669.14:669.1:669.735

STUDY OF PROPERTIES AND STRUCTURE OF DAMASCUS STEEL

Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 86, pp 4-5

[Article by Candidate of Technical Sciences V. R. Nazarenko]

[Abstract] A review of Soviet studies of Damascus steel is followed by a report on author's own work in which he studied the effect of carbon content between 0.75 and 4 percent on the appearance of the characteristic wavy pattern of Damascus steel in as-cast, forged, quenched, and quenched and tempered conditions. The Damascus pattern in forged and quenched and tempered steel appears at between 1.2 and 3.8 percent carbon. The pattern is attributed to simultaneous presence of cementite and pearlite in the structure. It is most pronounced at 2.2-3.2 percent carbon. A thorough study of heat treatment aimed at establishment of industrial production practice is recommended. References 6: all Russian.

12973/12955

CSO: 1842/258

UDC 621.762

INFLUENCE OF STRUCTURE ON LIFE OF TUNGSTEN-COPPER PSEUDOALLOYS DURING ELECTRIC EROSION WORKING OF HARD ALLOY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 14 Aug 85) pp 58-62

[Article by A. P. Gavrilenko, M. S. Kovalchenko, A. A. Kravchenko, V. V. Skorokhod, Yu. M. Solonin, N. I. Filippov and I. I. Karpikov, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] A study is made of the influence of the structure of tungsten-copper composites on their erosion life and productivity as electrode tools for dimensional electroerosion working of hard-alloy specimens. Tungsten-copper alloys obtained by saturation, hot pressing and liquid-phase sintering were studied. Elconite was found to have relatively short life, due to

its structural heterogeneity and presence of large grains of tungsten. Composites with good dispersion of components and relatively uniform distribution of components had the longest life. References 17: 16 Russian, 1 Western.

6508/12955  
CSO: 1842/54

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#### PHYSICAL AND MECHANICAL PROPERTIES OF POROUS Ti-BASED POWDER MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 10 Oct 85) pp 53-56

[Article by A. G. Kostornov, L. G. Galstyan, S. A. Mnatsakanyan and S. M. Agayan, Institute of Materials Science Problems, UkSSR Academy of Sciences, and Yerevan Polytechnic Institute]

[Abstract] An experimental study of porous Ti-based Cu-alloyed powder materials was made, for the purpose of determining the dependence of their electrical conductivity and mechanical strength characteristics on the porosity level and the sintering temperature. The basic material for this study was electrolytically refined PTEM-2 titanium powder of the 63-100  $\mu\text{m}$  grain size fraction. This material was further annealed at a temperature of 700°C under vacuum for 1 hr, for removal of oxide film and purging of gases. The powder was then mixed with 7% PMS-1 copper powder of the 40-100  $\mu\text{m}$  grain size fraction, the aim being to lower the required sintering temperature without sacrifice in strength characteristics. Porosity of specimens was attained and varied over the 25-70% range by addition of 5-30% stearin as plasticizer and stirring the mixture with a paddle wheel at a temperature of 65-70°C, prior to sintering at 1050°C or at 1100°C for 3 h in an argon atmosphere prepurified of oxygen and water vapor by means of titanium sponge and KOH concentrate at 600-700°C. The specimens thus produced were tested at room temperature for dependence of the electrical conductivity and the mechanical characteristics (ultimate tensile strength, shear strength, flexural strength, toughness under impact by a pendulum with a 15 J energy load) on the porosity of the two materials sintered at the two different temperatures. The data indicate that sintering at 1100°C results in higher electrical conductivity and mechanical strength at any porosity level. All properties as well as the quality of intergranular contact were found to decrease rapidly with increasing porosity, to approach zero as the porosity exceeded 60%. References 8: 7 Russian, 1 Western.

2415/12955  
CSO: 1842/55

## THERMAL DIFFUSIVITY OF TUNGSTENLESS ALLOY STIM-3B

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 23 Apr 85) pp 75-79

[Article by A. N. Yemelyanov and Yu. S. Karimov, Department of the Chemical Physics Institute, USSR Academy of Sciences]

[Abstract] For the purpose of evaluating the tungstenless special hard alloy STIM-3B, produced by self-propagating high-temperature synthesis and consisting of the compound carbide  $\text{TiC-Cr}_3\text{C}_2$  embedded in a Ni matrix, its thermal diffusivity was determined experimentally and compared with that of the TiNi20 hard alloy and of the WCo6 tungsten alloy. Square specimens with a  $12 \times 12 \text{ mm}^2$  area were cut from 1 mm thick plates by the electric-spark method and ground down to 0.2-0.4 mm thickness. In preparation of the STIM-3B alloy the amount of Ni matrix acting as binder for the carbide grains was varied from 0 to 21% through intermediate steps of 5% and 10%, with the porosity of specimens then correspondingly increasing from 1% with the binder to 12% without. Thermophysical measurements covering the 800-1400 K range were made by the method of plane temperature waves after specimens had been stress-relieved and degassed by annealing at a temperature of 1300 K under a vacuum of  $1.3 \cdot 10^{-3} \text{ Pa}$  for several hours. The data could be fitted on four approximately straight lines, each corresponding to a different Ni content. Subsequent calculations have yielded the temperature dependence of the thermal conductivity according to the Landauer-Bruggman relation and the dependence of the thermal diffusivity on the vol.% Ni content. The results indicate that, in terms of thermal conductivity, the STIM-3B alloy is comparable with the TiNi20 alloy but inferior to the WCo6 alloy. The authors thank A. G. Merzhanov for helpful discussion and A. N. Pityulin and Ye. N. Borisov for supplying specimens of the STIM-3B alloy. References 13: 11 Russian, 2 Western.

2415/12955

CSO: 1842/55

UDC 539.431

## OPTIMIZATION OF DETERMINING ENDURANCE LIMIT FOR GAS-TURBINE ENGINE BLADES

Kiev PROBLEMY PROCHNOSTI in Russian No 11, Nov 86 (manuscript received 21 Jan 85) pp 21-23

[Article by B. F. Balashov, V. P. Kharkov and Z. Kh. Yurovskiy, Moscow]

[Abstract] The standard method of determining the endurance limit for gas-turbine engine blades is to start the fatigue test with a stress amplitude  $\sigma$  about 10-30% above the expected limit for a given base number of cycles  $N_b$  representing the required life expectancy and then, if the blades

fracture before that number of cycles has been reached, to decrease the stress amplitude stepwise for subsequent blades till that life expectancy has been realized. Both testing time and cost can be minimized with the aid of prior computer simulation of the testing process, using an algorithmic random numbers generator for plotting the fatigue curve: a straight  $\log \sigma - \log N$  line with a normal distribution of  $\log N$  for most structural materials. The standard deviation can, in the first approximation, be also regarded as a linear function of  $\log \sigma$ . Application of this procedure to gas-turbine engine blades has yielded the optimum steps of load reduction depending on the steepness of the fatigue curve and has allowed reducing the number of blade sample lots from six to four without decreasing the reliability of the results at either 0.5 or 0.95 confidence level. References 1: Russian.

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#### DELAYED FRACTURE OF EI607A ALLOY UNDER COMPOUND THERMOMECHANICAL LOAD

Kiev PROBLEMY PROCHNOSTI in Russian No 11, Nov 86 (manuscript received 21 Jan 85) pp 26-29

[Article by P. A. Pavlov, V. Kh. Bronz and A. P. Novikov, Leningrad Polytechnical Institute, Leningrad]

[Abstract] Specimens of the EI607A heat-resistant alloy were tested for fracture under constant or stepwise variable compound thermomechanical load. The tests were performed on thin tubular specimens in a UME-10TM machine with a special device for simultaneous loading in tension and torsion. The loading modes were determined by the true dimensions of test samples at each instant of time according to computations on the basis of stress-strain relations, with the aid of empirical data, and on the basis of the generalized Pisarenko-Lebedev strength criterion. In the nonisothermal tests the temperature was changed stepwise up or down in two steps (700-750°C, 750-700°C, 700-650°C) or in three steps (650-700-750°C, 750-700-650°C), variously combined with stepwise changes of the mechanical load and with the holding time at each temperature ranging from 7 h to 25 h. Theoretical evaluation of the test results, with a statistical analysis of meager data, indicates the trend of the fracture kinetics under such loading conditions, without or with instantaneous plastic deformation, and, in the latter case, the effect of momentary plastic strains superimposing on viscoplastic creep strains. References 6: all Russian.

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DEPENDENCE OF FATIGUE RESISTANCE OF RUNNER BLADES MADE OF EP539LM CAST HEAT-RESISTANT ALLOY FOR GAS-TURBINE ENGINES ON TEMPERATURE, PROTECTIVE COATING, AND OPERATING TIME

Kiev PROBLEMY PROCHNOSTI in Russian No 11, Nov 86 (manuscript received 25 Dec 84) pp 47-51

[Article by V. I. Romanov, B. A. Gryaznov, A. A. Rabinovich, O. G. Zhiritskiy, I. S. Malashenko, L. A. Zaslotskaya, I. L. Meyerson, I. A. Makovetskaya, G. G. Bunin, Yu. S. Nalimov and Ye. G. Konoplyanikov, Strength Problems Institute, UkSSR Academy of Sciences, Kiev]

[Abstract] Blade specimens made of the EP539LM cast heat-resistant alloy for runner blades of gas-turbine engines were tested for fatigue strength in a BUS-20/5000 machine with electrodynamic excitation and a special device for high-frequency loading. Bare blades and blades with protective coatings were tested at room temperature (293 K) and at 973-1073-1173 K (in furnace or with heating by high-frequency electric current), Co-Cr-Al-<Y> coatings most adequate for modern high-pressure turbines having been deposited by electron-beam vacuum evaporation. For comparison, the surface of some blades had been protected by thermodiffusional impregnation of Al or Al+Si. Composite heating of blades by high-frequency electric current ensured a uniform temperature distribution over blade cross-sections, while thermocouples installed around the blade profile read the longitudinal temperature distribution over the blade surface. The mechanical test data, combined with theoretical solution to the heat conduction problem and the thermoelasticity problem for the given blade geometry, as well as microstructural examination and corrosion data, indicate a superiority of a Co-Cr-Al-Y coating deposited by the electron-beam method in terms of adequate protection with minimum decrease of the fatigue limit.

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CSO: 1842/44

UDC 620.18:620.17:621.9.04:533.9

STRUCTURE AND MECHANICAL PROPERTIES OF MASSIVE METALLIC GLASSES OBTAINED BY DETONATION-GAS ATOMIZATION

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian, No 11, Nov 86, pp 59-60

[Article by T. P. Shmyreva, I. Ye. Dolzhenkov and A. I. Karnaukh, Dnepropetrovsk Metallurgical Institute]

[Abstract] Information on the causes of failure of materials can frequently be obtained by fractographic analysis. In this article, a scanning electron microscope was used to study fractures in thin and massive metallic glasses

of the alloy Fe-P<sub>13</sub>-C . Thin amorphous specimens were obtained by hardening a jet of the alloy on a rapidly spinning copper disk; massive amorphous specimens about 2 mm thick were produced by detonation atomization. One characteristic peculiarity of the massive metallic glasses obtained by the detonation-gas atomization method is their layer-by-layer build-up on a massive metallic substrate by successive atomization of small portions of crystalline powder. Each layer is about 5 to 10  $\mu$ m thick, achieving a cooling rate of  $10^6$  K/s which is sufficient to produce the solid amorphous state. The nature of the fracture of the specimens was found to be independent of specimen thickness. Though looking like viscous fractures of crystalline materials, closer analysis of the surface reveals a number of peculiarities. The pits are asymmetrical and irregular, differing widely in size, with stretched, thinned ridges between pits oriented in the direction of failure. Thin layers enriched with light elements are found, the distance between them correlating with the thickness of the individual atomized layers, a result of repeated oxide film formation. Failure of the massive specimens probably begins with the oxide layers, producing the pits which follow the contours of the droplet particles. References 8: 7 Russian, 1 Western (in Russian translation).

6508/12955  
CSO: 1842/61

UDC 539.389.2:532.593:620.178.746:620.187.5.669.13

#### EFFECT OF BLAST LOADING ON FRACTURE MICROMECHANISMS IN STRUCTURAL STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12, Dec 86, pp 20-22

[Article by I. N. Gavril'yev, T. M. Sobolenko and S. P. Yakovleva]

[Abstract] Blast loading, with and without subsequent heat treatment, of killed low-carbon steel MSt3 and low-alloy steel 20Mn2Si was done for a determination of its effect on surface cracking and the fracture mode. Specimens of these steels were blasted with pressures of 5 GPa and 10 GPa, some being then briefly annealed at a temperature of 700°C. Following the treatment, specimens were tested mechanically in flexure and in impact till rupture at room temperature and at low temperatures down to -40°C. The tests were followed by metallographic examination of the fracture surfaces under a UEVM-100K electron microscope by the method of replicas and fractographic analysis. The results indicate a higher level of local microstrains and contortion of the surface relief with attendant discrete jumpwise cracking along intricate trajectories as a result of blast treatment. Subsequent heat treatment was found to increase the resistance to brittle fracture, especially at low temperatures. References 6: all Russian.

2415/12955  
CSO: 1842/62

## WEAR RESISTANCE OF CARBURIZED AND NITRIDED LAYERS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12,  
Dec 86, pp 24-27

[Article T. Burakowski, J. Senatorski and J. Tacykowski, Polish People's  
Republic]

[Abstract] A study of case hardened 18CrMnTi steel (0.20% C, 1.15% Cr, 0.95% Mn, 0.08% Ti) was made at the Institute of Precision Mechanics (Poland) for a comparative evaluation of carburized and nitrided layers with respect to wear resistance under friction. Carburizing was done at 930°C for h in an atmosphere with a 0.85% C potential, followed by quenching and then tempering at 180°C for 2 h. Nitriding was done at 530°C for 30 h or 6 h in an atmosphere with the N<sub>2</sub> potential controlled so as to prevent formation of the brittle  $\epsilon$ -phase. Nitrided specimens were ground 0.1 mm deep (after 30 h) and 0.04 mm deep (after 6 h), while carburized specimens were ground 0.2 mm deep. Wear tests were performed in hybrid sliding-rolling friction against conical rollers (height 13 mm, base diameters 12 mm and 23 mm) made of St45 carbon steel prehardened to Rockwell C 30 and rotating at a speed of 576 rpm, with the initial load pressure raised stepwise from 50 to 600 MPa and Luz-10 oil used as lubricant. The results indicate that carburizing and nitriding have approximately the same case hardening effect on this particular steel. In each case a surface hardness exceeding Vickers 700 was attained and the wear resistance was found to decrease with increasing depth below the original surface, a load pressure of 400 MPa or higher causing seizure. References 3: 1 Russian, 2 Western.

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UDC 620.17:669.018.45

## PROPERTIES OF CHAIN ALLOY TsMo-10

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12,  
Dec 86, pp 31-34

[Article by N. N. Morgunova, L. N. Demina and N. I. Kazakova, Central  
Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin]

[Abstract] The new vacuum-smelted cast or wrought molybdenum alloy TsMo-10 (0.001-0.003% B, 0.005-0.5% Al,  $\leq$  0.009% C,  $\leq$  0.004% N,  $\leq$  0.002% O<sub>2</sub>) for chains is highly formable and weldable. Its metallurgical characteristics, particularly recrystallization temperature-time relation, were determined on strip and rod specimens by annealing in a tubular vacuum furnace at temperatures of 900-1100°C for lengths of time ranging from 1 min to 50 h. Stress relief and stabilization of properties were attained by tempering

at 900°C, well below the recrystallization temperature. Specimens were then tested mechanically in flexure at temperatures from -100°C to +100°C for determining the temperature dependence of tensile strength, 0.2% yield strength, and percentage elongation, as well as for establishing the cold-shortness threshold. The results indicate that the mechanical properties and heat resistance are on par with those of pure molybdenum, its embrittlement temperature being in the subzero range and thus lower than that of most other Mo alloys such as the commercial TsMo-2A.

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UDC 620.17:669.28'293:621.785.532

#### STRUCTURE AND MECHANICAL PROPERTIES OF Mo-Nb SINGLE CRYSTALS AFTER NITRIDING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12, Dec 86, pp 34-37

[Article by M. Yu. Belomytsev and B. G. Belyakov, Moscow Steel and Alloys Institute]

[Abstract] Treatment of Mo-Nb alloys by internal nitriding of their single crystals was studied for a determination of the effect on their structure and mechanical properties. Single crystals of Mo + (0-5.8%) Nb were nitrided at temperatures of 1400-2000°C with pure N<sub>2</sub> (without H<sub>2</sub>O and O<sub>2</sub>) under a pressure varied up to 0.8 MPa in a special apparatus and for lengths of time up to 50 h. Microstructural examination of thin cut foils under a "Tesla BS-613" transmission electron microscope with 100 kV accelerating voltage revealed precipitation of NbN as a disperse hardening phase. Flat cut specimens 1 mm thick were tested mechanically for tensile strength, 0.2% yield strength, and percentage elongation in the direction of the  $\langle 111 \rangle$  axis, with the 3x17 mm<sup>2</sup> faces parallel to the (110) plane, at temperatures of 1600°C and higher. Microhardness was measured under a 0.5 N load. The results indicate that strength and hardness increase appreciably with longer nitriding time and with higher N<sub>2</sub> pressure up to the Nb saturation and retention level. Data on three of these alloys with 1.5% Nb, 3.2% Nb, 5.8% Nb respectively reveal and increase of strength in this order and also a higher softening temperature in this order (1500°C, 1800°C, 1950°C) with a correspondingly increasing creep resistance. References 6: all Russian.

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CSO: 1842/62

## ALUMINUM-METALLIZING PROTECTS UNDERGROUND PIPES FROM CORROSION

Minsk NARODNOYE KHOZYAYSTVO BELORUSII in Russian Nov 86 p 32

[Article by V. Aksyuchits: "Aluminum Against Corrosion

[Text] A 12-meter long pipe slowly travels on roller supports. It is conveyed into a chamber equipped with burners, where it is flame-cleaned and degreased. Then it is cleansed of adhering dirt, scale, and rust by means of metal brushes. It obtains the necessary surface roughness in a shot-blasting chamber. Only then does the pipe go into a metallizing chamber.

There is a buzzing sound of an electric arc. Aluminum wire melts in the arc. A strong stream of air blows aluminum particles and "whips" them against the pipe surface. And they, so-to-speak, "stick" to the surface, bond to it tightly and form a strong, dependable protective layer. After a short time, the pipe is placed on a rack for finished products.

The entire process is controlled from a control panel by an operator and his helper

This is how an automated pipe-metallizing line, developed by a group of specialists from the Minsk Belspetsenergo enterprise of the Soyuzspetspremerenergo All-Union Production Association under the direction of the enterprise manager A. M. Priymak and chief engineer G. N. Astashonok, operates.

It is well known what a serious enemy of any metal structure corrosion is. It is especially damaging to underground utility pipes. For example, the life of central-heating mains is 5-7 years.

This is why the group of Minsk specialists had undertaken the development of a method for protecting central-heating mains from corrosion.

"It was our task to find a simple, inexpensive, and reliable method of protection", says G. N. Astashonok. "The importance of this task can be simply illustrated by the fact that in Minsk alone the length of the central-heating mains is more than 1000 kilometers. Increasing their service life means saving huge quantities of materials and the prevention of numerous breakdowns, repairs, and frequent replacement of pipes."

It was decided to metallize the pipes with aluminum. This method has been known for a long time. It is used in many countries to protect bridges, off-shore drilling rigs, and roofs. It has not found widespread use in the USSR owing to its high cost when aluminum is applied manually with a spray gun.

Metallization of central-heating pipes increases their service life to 15-20 years. And when the aluminum layer is impregnated with special compositions, as experience gained abroad indicates, the life of the pipes increases tenfold.

Therefore the idea occurred to develop mechanized lines for coating of pipes with aluminum. Attempts at developing them were made previously in our country. However, they were unsuccessful. The method of cleaning the air of aluminum dust was unsatisfactory. When the aluminum dust content of air reaches 40 grams per cubic meter, the resulting mixture is explosive. The Minsk specialists have dealt successfully with this problem. A metallizing chamber, simple in design, original, and reliable, and a method of trapping the aluminum dust were developed. The line was based on the work of doctor of technical sciences I. V. Strizhevskiy, head of the department for the protection of underground equipment from corrosion of the Municipal Services Academy imeni K. D. Pamfilov.

Doctor A. I. Pirumov, laboratory head of the Central Scientific Research and Experimental Planning Institute for Industrial Buildings and Structures, Zh. Ye. Shevtsova, engineer-designer of the enterprise, foreman G. I. Glaykhengauz, and installer N. P. Deyev took an active part in the work.

Thus the problem of the application of metallized coatings on 89 to 820 mm-diameter pipes was solved for the first time in our country. The cost of coating pipes with aluminum is 2.5 to 3 rubles per square meter, as compared to a cost for manual coating with a spray gun of 20-25 rubles per square meter. The coating line is capable of coating up to 100 kilometers of pipes a year. It can do it not only for central-heating pipes but also for other underground service lines.

It is presently planned to install and place in operation such lines in Mogilev and Novopolotsk.

And the specialists are now working on a method of automation for the application of metallized coatings not only on the outer but also on the inner pipe surface.

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## ULTRASOUND HARDENS METALS

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 17 Dec 86 p 2

[Article by V. Bogdanov, Kirov]

[Text] The hardness of the metal-cutting tools and stamping dies of the Elan-2 and Elan-3 units, developed at the Korovsk Electrical Machine-Building Production Association imeni Lapse, is being increased 1.5-3 times. The designers have found an original solution. They have used ultrasound, which induce vibrations in an electrode at the time when an electric spark discharge transfers metal particles from the electrode to the surface being treated. The result is an even wear-resistant layer. This does not dull the cutting edges of the tool, and the surface does not require a special pretreatment. The entire process is automated.

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## GRAPHITIZATION AND ALUMINIZING OF CAST-IRON CASTINGS CAST IN ALUMINUM MOLDS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 86 pp 2-3

[Article by Engineers V. I. Korsunskiy, S. P. Kozhemyakin and V. E. Veys and Candidates of Technical Sciences L. S. Olkhovoy and A. N. Yemelyushkin]

[Abstract] Gray-iron castings for electric-motor beds were graphitized and simultaneously aluminized at the Yaroslav Electric Machinery Plant with collaboration of the Magnitogorsk Mining and Metallurgical Institute by pouring and solidifying gray iron in aluminum molds and immersing the castings together with the molds in molten aluminum in order to melt the molds, remove the surface chill resulting from rapid cooling in aluminum molds, and graphitize and aluminize the iron. The optimum aluminum bath temperature both for graphitization and for the production of high-quality aluminum coatings was found to be 1120°K, but the graphitization of the chilled surface layer at this temperature takes longer than 30 minutes. This time can be shortened to 3 minutes by increasing the carbon and silicon contents of cast iron to less than 3 and 4 percent, respectively, and modifying the iron with 0.5 percent  $\text{Al}_2\text{O}_3$ , 0.5 percent Cu, 0.5 percent ferrosilicon FS75, and 0.5 percent Al. This treatment produces a 0.1-0.2 mm Al layer bonded to iron by a 25-50 micron intermetallic layer. References 1: Russian.

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## WEAR-RESISTANT PLASMA COATINGS BASED ON DOUBLE TITANIUM CARBIDE AND CHROMIUM

Kiev POROSHKOVAYA METALLURGIYA in Russian, No 10, Oct 86 (manuscript received 27 Mar 85) pp 46-47

[Article by V. B. Raytses, V. M. Litvin, V. P. Rutberg, Z. S. Nagorskaya and V. P. Brazhevskiy, Zaporozhye Industrial Institute]

[Abstract] A study is made of the possibility of creating wear-resistant plasma coatings by atomization of double titanium carbide and chromium powder. X-ray structural analysis of the powder reveals but a single phase, titanium carbide. The chromium is present in the atomic lattice of the titanium carbide as a solid solution of substitution. The quality and properties of the plasma coatings were found to depend on atomization conditions, particularly are voltage and current, the flow of plasma-forming and transport gases, and atomization distance. The method of mathematical planning of experiments was used to select optimal atomization conditions and determine the interrelationships of the various factors. The optimal conditions (not described) were used to atomize two series of specimens: unclad and carbide-clad. Characteristics of the coatings were tested. The clad coatings had lower density, lower porosity, lower adhesion, greater wear resistance and lower microhardness.

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## PREDICTING THICKNESS OF COATINGS DEPOSITED BY PLASMA SPRAY UNDER VARIOUS CONDITIONS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 11 Mar 85) pp 31-32

[Article by V. B. Raytses, V. S. Nagorskaya and V. P. Rutberg, Zaporozhye Industrial Institute]

[Abstract] For optimization of the plasma-spray coating process, the given thickness of the coating is proposed as the target function. The viability and the expediency of using this quantity as the optimizable parameter covering all possible process conditions are established by analysis of the characteristic conical process configuration, which leads to the definition of this parameter as  $T = \frac{t}{n} \frac{h}{h_0} \frac{v}{v_0}$  ( $t$ - thickness of layer deposited in  $n$ - passes,  $h$ - spray distance = height of cone,  $v$ - velocity of plasma spray gun moving parallel to the cone base) with  $h_0$  and  $v_0$  corresponding to some definite standard process conditions as reference.

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## PRODUCTION OF AMORPHOUS-CRYSTALLINE Ti-Ni COATINGS BY PLASMA SPRAY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 22 Jul 85) pp 36-38

[Article by N. P. Bolotina, T. V. Argunova and V. D. Tyunin, Physical Technical Problems of the North Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] An experimental study was made concerning the feasibility of producing amorphous or amorphous-crystalline Ti-Ni coatings by the plasma spray process. The process conditions had been selected so as to ensure optimum coating characteristics at the maximum possible deposition rate. Coatings were produced from PNi55Ti45 powder of the highly wear- and corrosion-resistant intermetallic compound TiNi in a standard UPU-3D apparatus using Ar-N<sub>2</sub> plasma. Microstructural examination and phase analysis of coating surfaces and cross-cuts were done in a DRON-1.5 x-ray diffractometer with CuK<sub>α</sub>-radiation and CoK<sub>α</sub>-radiation sources, after specimens had been etched with a mixture of hydrofluoric acid and glycerin. Metallographic examination was done under a "Neophot-21" microscope. The fine structure of the coatings was examined under a UEMV-100 electron microscope by the method of chrome-tinted carbon replicas and their chemical composition was determined in a "Geol" x-ray microanalyzer. The results indicate changes in the phase composition occurring during the coating formation process, with the oxide TiO and possibly the compound oxide NiTiO<sub>3</sub> appearing along the intermetallic compound TiNi and the amorphous phase - the principal two components which determine the coating characteristics. References 2: both Russian.

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UDC 621.793.6:669.018.45

## OPTIMIZATION OF COATING STEEL FOR HEAT RESISTANCE BY IMPREGNATION WITH Al-Si-Cr MIXTURES

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 22 Jul 85) pp 106-110

[Article by B. S. Kukharev, I. A. Basalay and L. S. Lyakhovich, Belorussian Polytechnical Institute]

[Abstract] Thermodiffusional surface impregnation of carbon steels St20, St45 and shock-resistant alloy steel U8 with Al<sub>2</sub>O<sub>3</sub>-Cr-Al-Si mixtures containing also a rare-earth metal for extra heat resistance was studied in a 3-factorial experiment for the purpose of optimizing the composition of that mixture:  $x_1$  - wt.% of 75CrO<sub>2</sub> + 25Al (7 levels),  $x_2$  - wt.% of 30Si

+ 30Ce - 40 fluoroboric salt as activator (9 levels), x<sub>3</sub>- wt.% Al (4 levels). Impregnation was done at a temperature of 950°C for 6 h to form heat-resistant surface layers 190 μm thick in St20 steel, 160 μm thick in St45 steel, and 130 μm thick in U8 steel. Regression analysis of the data has yielded the optimum impregnant composition for each steel, not very different for each steel, in terms of minimum loss of mass as function of time at various test temperatures. Microstructural examination and phase analysis by the x-ray diffraction method and Auger spectroscopy have revealed existence of the thermally stable Fe<sub>2</sub>Al<sub>5</sub> phase, which becomes alloyed with Ce and form FeAlO, and of the α-Fe<sub>3</sub>Al phase (solid solution) with variable Ce content depending on the impregnant composition. While the thickness of optimum and nonoptimum coatings was found to be almost the same, the volume ratio of those two phases differed appreciably with the Fe<sub>2</sub>Al<sub>5</sub> content increasing and its thickness almost independent of the carbon content in the steel. References 5: all Russian.

2415/12955  
CSO: 1842/46

UDC 669.187.2:537.533:621.187.1:(620.18+002.612)

#### DEPENDENCE OF STRUCTURE OF THICK Cr CONDENSATES ON TEMPERATURE OF THEIR VACUUM DEPOSITION

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 4, Oct-Dec 86 (manuscript received 24 Jul 85) pp 40-44, 58

[Article by G. I. Batalin, A. V. Kapitan, V. D. Kushkov, A. V. Melnikov, N. I. Grechanyuk and G. G. Didikin, Electric Welding Institute imeni Ye. Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] A study of vacuum-deposited Cr condensates was made for the purpose of establishing the causes of structural differences reported by various authors using various deposition processes. In this study 0.3-0.4 mm thick condensates of electrochemically refined Cr were produced by electron-beam evaporation under a vacuum of 10<sup>-3</sup> Pa and subsequent deposition from the vapor phase at a rate of 80 nm/s on substrates with a 500-1200°C longitudinal temperature profile. Prior coating of the substrates with a 10 μm thick ZrO<sub>2</sub> interlayer facilitated removal of the Cr condensates for metallographic examination under an MIM-8 optical microscope and under an REM-200 scanning electron microscope as well as phase analysis in a DRON-3 x-ray diffractometer. In addition, carbon replicas were examined under an EMV-100L plain electron microscope. The results indicate zonal precipitation of Cr, characterized by conical formations, principally crystalline with a cubic lattice at temperatures of 500-800°C and much smoother at temperatures of 1000-1200°C. The first zone, formed at temperatures below 800°C, is a film of very fine grains without secondary growth. In the second zone, formed at temperatures above 800°C, self-diffusion occurs with resulting coagulation into crystal seeds upon collisions. In the third zone, also formed at temperatures above 800°C, uniaxial secondary recrystallization of

primary columnar grains occurs. Discrepancies between structural data and, particularly, recorded phase boundary temperatures are attributable to different condensation rates, different degrees of condensate purity, and different substrate finishes. References 11: 3 Russian, 8 Western (3 in Russian translation).

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CSO: 1842/49

UDC 669.187.2:669.24'25'71:539.292

PHASE TRANSFORMATIONS AT BOUNDARY BETWEEN MODEL Ni-Co-Cr-Al ALLOYS AND HEAT-RESISTANT Ni-Cr ALLOYS

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 4, Oct-Dec 86  
(manuscript received 11 Apr 85) pp 45-49

[Article by V. S. Litvinov, V. G. Kagan and V. P. Lesnikov, Electric Welding Institute imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] Protective cladding of heat-resistant Ni-Cr alloys with Ni-Co-Cr-Al alloys by electron-beam evaporation under vacuum is considered, a study of structural and phase transformations at the boundary between base alloy and cladding alloy having been made for a better understanding of the diffusion process. Two commercial Ni-Cr alloys, ZhS6W and cast EP539Mo, were clad with four different special alloys containing 18% Cr and 12% Al each but varying amounts of Ni and Co (70% Ni, 60% Ni + 10% Co, 40% Ni + 30% Co, 70% Co). These alloys had been produced by smelting in an electric-arc furnace in an argon atmosphere (99.99% pure Ni, 99.8% pure Co, 99.7% pure Cr, 99.95% refined Al), ingots of these alloys having been annealed at a temperature of 1100°C for 8 h. Microstructural examination and phase analysis of the diffusion layer by microhardness measurement and x-ray spectral microanalysis have revealed migration of Co from the cladding alloy into the base alloy, displacing Ni and causing its concentration to correspondingly increase across the diffusion zone, also a redistribution of W or Mo in the diffusion zone, and a minute precipitation of binary carbides  $(\text{Ni,Co,Cr})_m(\text{Mo,W})_nC$  along with  $\text{TiC}$  and  $\text{CrC}$  in the diffusion zone near the base alloy. References 6: 4 Russian, 2 Western.

2415/12955  
CSO: 1842/49

## CORROSION RESISTANCE OF VACUUM-DEPOSITED THICK Cu-Mo CONDENSATES IN AQUEOUS MEDIA

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 4, Oct-Dec 86  
(manuscript received 17 Jun 85) pp 50-53

[Article by V. G. Grechanyuk, B. M. Yemelyanov, D. K. Zabolotskaya, V. I. Topal, I. F. Rudenko and A. I. Babarik, Kiev Construction Engineering Institute and Electric Welding Institute imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] Corrosion tests were performed on 0.8-1.2 mm thick Cu-Mo condensates in tap water, such condensates in the form of 350x250 mm<sup>2</sup> large plates having been produced by direct electron-beam evaporation under vacuum with the Mo content varied over the 0-11% range. Specimens with a surface area of 1 cm<sup>2</sup> were cut from these plates, annealed, and placed in water for 100 h for both static and dynamic tests. In the latter case the water remained still while specimens mounted on disks rotated at a constant speed of 60 rpm. Gravimetric change-of-mass readings were taken and chemical analysis of the water was performed in 20 h intervals. The data have been evaluated, taking into account oxidation of Cu to CuO and of Mo to MoO<sub>3</sub>, the two metals not interacting with one another, as well as ionic reactions in water containing Ca<sup>2+</sup> and Mg<sup>2+</sup> ions. For comparison, similar tests were run in distilled water. The results confirm the hypothesis that Mo<sup>3+</sup> ions enter the water under static conditions and form an MoO<sub>3</sub> film under dynamic conditions. The corrosion resistance of these condensates was found to depend on the Mo content as well as on the water composition and the test conditions, a low Mo content up to 5% having almost no effect but a Mo content above 5% lowering the corrosion resistance appreciably. References 5: all Russian.

2415/12955

CSO: 1842/49

UDC 669.187.2:537.533:621.187.1:(539.2+620.17).001.5

## STRUCTURE AND PROPERTIES OF VACUUM-DEPOSITED THICK Cr-Si CONDENSATES

Kiev PROBLEMY SPETSIALNOY ELEKTROMETALLURGII in Russian No 4, Oct-Dec 86  
(manuscript received 20 Jul 84) pp 54-58

[Article by N. I. Grechanyuk, G. G. Didikin, T. A. Molodkina and B. A. Movchan, Electric Welding Institute imeni Ye. O. Paton, UkSSR Academy of Sciences, Kiev]

[Abstract] A study of 1.0-1.2 mm thick Cr-Si binary condensates with 1.4-4% Si was made for a determination of their structure and mechanical properties, such condensates in the form of 360,220 mm<sup>2</sup> large plates having been produced

by separate electron-beam evaporation of Cr and Si with their subsequent deposition from the vapor phase on substrates at a temperature of  $850 \pm 10^\circ\text{C}$ . The source of Cr were ingots of commercial CrO grade (0.020% C, 0.38% Fe, 0.27% Ni, 0.21% Si, 0.06% Al, 0.06% Ti, 0.002% Cu, 0.186% N<sub>2</sub>, 0.104% O<sub>2</sub>), 70 mm in diameter, produced by smelting in an induction furnace in an argon atmosphere. The source of Si were pure ingots, also 70 mm in diameter. Chromium was evaporated under a vacuum of  $1.33 \cdot 10^{-2}$  Pa and deposited at a rate of  $0.5 \mu\text{m/s}^{-1}$ , the Cr evaporator being located 230 mm away from the Si evaporator and both evaporators being located 300 mm away from the substrate. Prior deposited thin ZrO<sub>2</sub> interlayers facilitated removal of the condensates for subsequent annealing at temperatures of  $900^\circ\text{C}$  for 1 h or  $1100^\circ\text{C}$ ,  $1200^\circ\text{C}$ ,  $1300^\circ\text{C}$  for 5 h, each under a vacuum of  $1.33 \cdot 10^{-2}$  Pa. Structural and phase contents of the condensates were determined on the basis of quantitative metallographic analysis, examination under a transmission electron microscope, and microhardness measurements in a PMT-3 tester. Mechanical strength and plasticity were determined in bending tests with a loading rate of  $1.7 \cdot 10^{-2} \text{ mm/s}^{-1}$  at room temperature. The structure of the condensates was found to consist principally of columnar grains oriented in the direction of vapor flow and a randomly distributed Si second phase. While the plasticity of Cr condensates was found to be very low, fracture occurring upon bending through an angle not larger than  $0.5^\circ$ , addition of 1.5-3.8% Si was found to increase the plasticity appreciably up to a  $17.5^\circ$  bending angle and the strength by 980 MPa with an attendant decrease of proneness to brittle fracture. Addition of more than 3.8% Si restored the proneness to brittle fracture. Maximum plasticity attained by addition of Si was retained after annealing at temperatures up to  $1300^\circ\text{C}$ . References 3: 1 Russian, 2 Western (1 in Russian translation).

2415/12955  
CSO: 1842/49

UDC 539.292:532.529.2+532.5:51

# ON THE MECHANISMS OF CONVECTIVE AGITATION DURING THE PULSE MELTING OF METAL SURFACES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 291, No 4, Dec 86  
(manuscript received 25 Nov 85) pp 843-847

[Article by R. V. Arutyunyan, L. A. Bolshov, V. V. Vityukov and V. P. Kiselev]

[Abstract] Numerical methods were used to construct a mathematical model of the process by which convection sets in during the pulse heating of metal surfaces. The following constraints were used: a melt zone was designated within a rectangular space with impermeable borders; at the initial temporal moment, the surface layer of the melt had a tangential speed, and the rest of the fluid was in a quiescent state; the upper layer of the fluid was considered to be saturated with admixture; the space contained one half-wave, and the impermeable walls allowed the solution to

be periodically continued in both directions. To construct a numerical model of the transient flow of the melt, equations for the motion of a viscous, non-compressed fluid on an Euler grid were solved, taking surface tension into account. Distribution of the admixture was modeled using particle markers that moved together with the fluid. After striking an impermeable wall, the moving surface layer of the fluid basically travelled upwards. The fluid stopped moving due to surface tension and began generating non-linear capillary waves. Two variations of the model were examined. In the first, the effect on the substance of pulses several microseconds in length was modeled. The melt was 30  $\mu\text{m}$  long and 10  $\mu\text{m}$  deep. The admixture zone and the depth of the accelerated layer were both 3  $\mu\text{m}$ . The range of velocities was  $5 \cdot 10^2 < v < 1.5 \cdot 10^3$  cm/second. In the second variation, the length of the melt zone was 200  $\mu\text{m}$ , and the depth was 50  $\mu\text{m}$ . The admixture zone was 10  $\mu\text{m}$ , and the depth of the accelerated zone was 10 and 25  $\mu\text{m}$ . Velocity was  $2 \cdot 10^2$  cm/second. In both cases, the melt was effectively agitated in less than 1000 mcs. Thus, effective agitation of the melt without splashing takes place within a sufficiently wide range of parameters typical for experiments on laser pulse alloying. References 8: 5 Russian, 2 Russian/Western, 1 Western.

13050/12955  
CSO: 1842/56

UDC 669.14.018.258.29:621.785.53

#### CHROMIUM IMPREGNATION OF BALL-BEARING STEELS FOR LONGER LIFE OF BALL BEARINGS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12, Dec 86, pp 5-10

[Article by G. N. Dubinin, G. L. Oganessian, V. P. Zhukov and V. A. Boykov, Moscow Institute of Civil Aviation Engineers and All-Union Scientific Research and Design Technological Institute of the Ball Bearing Industry]

[Abstract] An experimental study of special ball-bearing steel ShCr15 and two other steels, 95Cr18 and 55SiMo5VN, used for ball bearings was made for the purpose of determining the effect of chromium impregnation on bearing life. Following standard heat treatment, specimens of these steels were chromized by the standard method at temperatures of 950-1050°C for 1-9 h. Microstructural examination of the 15-25  $\mu\text{m}$  thick diffusion layers revealed a fairly uniform dislocation density profile with only a narrow sharp peak and attendant high residual stresses at the surface. Phase analysis by the x-ray diffraction method and Auger spectroscopy revealed a redistribution of elements with an 81-90% Cr content at the surface and identified carbonitride  $(\text{Cr,Fe})_2\text{NC}$  along carbides  $(\text{Cr,Fe})_{23}\text{C}_6$  and  $(\text{Cr,Fe})_7\text{C}_3$  within the diffusion layer. Specimens, of steels so treated, as well as specimens after standard heat treatment alone and specimens after chromium impregnation alone, were tested for wear at a rubbing velocity of 0.6 m/s under a load pressure of 118 kPa. The steels were tested for

corrosion in aqueous 4% NaCl solution at normal temperature. The data reveal a close correlation between residual stress, work function, and relative wear resistance. Bearings of Sh2 type and Sh8 type were tested in a machine rocking at a frequency of 0.5 Hz through a  $\pm 30^\circ$  angle under a 0 - 34.80 kN - 0 load cycle as well as under a light load of 3.2 kN for inspection after every 5000 cycles. The results indicate that chromium impregnation increases both wear and corrosion resistance of all three steels so that the less expensive ShCr15 steel can be safely substituted for the more expensive 95Cr18 steel. The residual stresses were measured with assistance of N. S. Merkulova; the work function was measured with assistance of Ye. V. Ivankushenko. References 4: 3 Russian, 1 Western.

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CSO: 1842/62

UDC 539.2:678.067

## WOVEN FRAMEWORKS FOR THREE-DIMENSIONAL REINFORCEMENT

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 2 Apr 86) pp 795-799

[Article by A. M. Tolks, I. A. Repelis, M. P. Gailite and V. A. Kantsevich,  
Polymer Mechanics Institute, Latvian Academy of Sciences, Riga; Riga Poly-  
technical Institute imeni A. Ya. Pelshe]

[Abstract] A study is made of the structure of a group of reinforcing frameworks with three-dimensionally curved (woven) placement of reinforcing elements formed by a system of three filaments. The frameworks can be made using standard looms and are suggested for the manufacture of structural and insulating composites. Alternate weaving schemes are described and illustrated. Weaving technology allows the manufacture of body fill, envelope and rod structure woven frameworks with mean framework densities of up to 0.7-0.79 g/cm<sup>3</sup> for carbon graphite filaments and 1.4-1.5 g/cm<sup>3</sup> for glass or quartz filaments. Elastic characteristics of composites using these frameworks are estimated as  $E=70$  GPa,  $\nu=0.25$  for glass fiber,  $E_1=230$  GPa,  $E_2=E_3=7.5$  GPa,  $G_{12}=G_{13}=57$  GPa,  $\nu_{21}=\nu_{31}=0.03$ ,  $\nu_{23}=\nu_{32}=0.07$  for carbon fiber, for which  $E=2.9$  GPa,  $\nu=0.37$  for the framework. References 20: 14 Russian, 6 Western.

6508/12955

CSO: 1842/50

## THERMAL DEFORMATION AND STRENGTH OF COMPOSITE MATERIALS AT HIGH TEMPERATURES

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 6 Jan 86) pp 800-805

[Article by G. N. Tretyachenko and L. I. Gracheva, Strength Problems Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] Nonmetallic composite materials may undergo physical and chemical transformations when heated, converting the materials to porous composites consisting of coke hardened by carbon, silicone, metal or other fibers. When materials are heated they may initially expand but then undergo significant shrinkage. Thermocouple monitoring of such products does not reveal the complexities of the process in small volumes of the products. Some examples of phenomena occurring in such products are reported, including development of anisotropy of expansion and contraction; variation of strength following heating with heating rate and chemical composition of the medium, strength dropping by 40 to 60% as heating rate rises from 10 to 100°C/min in shell specimens and almost by a factor of three in plates; variation in strength and plasticity with scale factor; continuation of rapid shrinkage upon natural cooling, rather than a return to the initial state; and the negative influence of thermal cycling. The examples indicate that carbon materials, though quite promising for their high temperature strength, require further development to assure stability of properties. References 8: all Russian

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CSO: 1842/50

UDC 539.2:539.4:678.067

## STRUCTURE AND STRENGTH OF BORON-ALUMINUM COMPOSITES

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 10 Jan 86) pp 811-819

[Article by S. T. Mileyko, F. Kh. Suleymanov and N. S. Sarkisyan, Solid State Physics Institute, USSR Academy of Sciences, Moscow]

[Abstract] The authors suggest, as a basis for interpretation of experimental data on the strength of boron-aluminum composites as a function of hot pressing or annealing temperature and time, a model of the failure of such a composite containing a brittle fiber, indicating the possibility of non-monotonic variation in composite strength as a function of volumetric fiber content. Experiments were performed involving production of boron-aluminum specimens, their annealing at various temperatures and times, and mechanical tensile testing with determination of the volumetric fiber content in each specimen, examination of the fracture surface, and measure-

break-up, as well as intersection of the fiber zones of influence. The long term strength curve bends at a certain value of the temperature-time parameter. References 19: 13 Russian, 6 Western.

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CSO: 1842/50

UDC 539.4:539.2:666

#### CRACK RESISTANCE OF MULTILAYER CERAMIC-BASED COMPOSITE MATERIAL

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 13 Jan 86) pp 836-840

[Article by S. M. Barinov, D. A. Ivanov and G. A. Fomina, Moscow Aviation Technological Institute imeni K. E. Tsiolkovskiy; Metallurgy Institute, imeni A. A. Baykov, USSR Academy of Sciences, Moscow]

[Abstract] The possibility of increasing crack resistance of ceramic composite materials by changing the orientation of the crack by crack deflection has been theoretically demonstrated and preliminary studies have established that the effect can be achieved in layered structure ceramic materials. This article presents results of studies of the crack resistance and kinetics of the process of fracture in such materials. Crack resistance characteristics were determined under bend test conditions in prism specimens with side notch on an Instron-1115 machine. Maximum critical stress intensity factor and specific effective work of fracture,  $4.0 \text{ MPa}\cdot\text{m}^{1/2}$  and  $250 \text{ J/m}^2$ , were achieved for aluminum oxide with layered structure. These parameters were  $6.0 \text{ MPa}\cdot\text{m}^{1/2}$  and  $1,000 \text{ J/m}^2$  for a composite of  $\text{Al}_2\text{O}_3$ -Cr containing 30% Cr with layered structure. The fracture of the layered materials was discrete, accompanied by branching of cracks on interlayer boundaries and layered cell boundaries. Fracture of layered aluminum oxide material occurred in stages of acceleration and deceleration of crack growth due to changes in crack orientation with respect to the direction of application of maximum tensile stresses. References 4: 3 Russian, 1 Western.

6508/12955  
CSO: 1842/50

## OPTIMAL FILAMENT SHELLS LOADED WITH INTERNAL PRESSURE IN A CENTRIFUGAL FORCE FIELD

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 13 Jan 86) pp 859-864

[Article by S. B. Cherevatskiy, V. M. Kotlyar and S. G. Sidorin, Kazan Chemical-Technological Institute imeni S. M. Kirov]

[Abstract] A study is made of planning optimal network- shells of rotation loaded with internal pressure, as well as shells in a field of centrifugal forces. The problem of designing the optimal shell is reduced to seeking the form of the meridian of the surface, the thread winding trajectory and forces in the network. Results of the numerical analysis performed are presented in tabular form. An optimal winding scheme is developed which produces a shell 10-15% stronger than a geodesic shell. References 2: both Russian.

6508/12955  
CSO: 1842/50

## MONOLITHIC NATURE OF TRANSVERSELY REINFORCED COMPOSITES

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian, No 5, Sep-Oct 86  
(manuscript received 8 Jan 86) pp 883-887

[Article by V. T. Tomashevskiy, V. N. Shalygin, G. V. Dodin, R. S. Zinoyev and A. N. Pimenov, Naval Academy imeni Marshal of the Soviet Union A. A. Grechko, Leningrad; Leningrad Mechanics Institute imeni Marshal of the Soviet Union D. F. Ustinov]

[Abstract] The influence of supplementary transverse reinforcement by means of short-fiber microparticles on temperature stresses in a cylindrical reinforced shell as it is cooled following heating is studied by a finite-difference method. Three factors are found to improve the monolithic properties of the products with the short transverse reinforcing elements: the increase in transverse tensile strength; the decrease in transverse tensile strength variation; and the decrease in effective temperature stresses. Furthermore, microstructural studies show that microscopic cracks in the polymer layers, generated in the intervals between transversely oriented particles, propagate only as far as the surfaces of the particles. The particles therefore do not serve as stress concentrators. An algorithm is developed for the planning of wound composite products with guaranteed preservation of monolithic characteristics at the planned usage temperatures. A flow chart for the algorithm is presented. References 5: all Russian.

6508/12955  
CSO: 1842/50

## STUDY OF STRENGTH CHARACTERISTICS OF GLASS-REINFORCED PLASTIC BY ACOUSTIC EMISSIONS METHOD

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 3 Dec 85) pp 920-924)

[Article by Ye. S. Pereverzev, D. G. Borshchevskaya, G. A. Bigus, V. G. Tikhiy, T. S. Tremba and V. A. Limonov, Technical Mechanics Institute, Ukrainian Academy of Sciences, Dnepropetrovsk]

[Abstract] Results are presented from studies of the nature of fracture of glass-reinforced plastic based on FO-1-1 knitted glass fabric and EDT-10 resin using data on acoustical activity. The effectiveness of quality control of products made of this material in testing is calculated. Specimens are loaded in uniaxial extension at 0.07 to 0.3 MPa/s with internal pressure 0.2 MPa/s as acoustical emissions were recorded. The frequency, amplitude and shape of the acoustical pulses were considered. The acoustical pulses were found to reveal the nature of damage accumulating in the material in all stages of loading and to allow selection of critical recommendations for the use of this method for nondestructive testing of products and prediction of their strength properties. Large numbers of low energy pulses were recorded during break-up, delamination and rupture of knitted glass fibers, followed by higher power pulses emitted upon failure of the binder. References 5: 3 Russian, 2 Western (1 in Russian translation).

6508/12955  
CSO: 1842/50

UDC 542.915

## MICROPROBE EXAMINATION OF COMPOSITE MATERIALS PRODUCED BY BURNING OF Ti, Cr, C POWDERS WITH POWDER OF ANY ONE Fe-GROUP METAL

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 11, Nov 86 (manuscript received 4 Mar 85) pp 1842-1844

[Article by A. S. Rogachev, Yu. A. Galchenko, Z. G. Aslamazashvili and A. N. Pityulin, Chemical Physics Institute, USSR Academy of Sciences]

[Abstract] A study of composite materials produced by burning of Ti, Cr, C powder mixtures with powder of any one Fe-group metal was made for a determination of their phase composition and microstructure, these materials having properties comparable with those of WC-base alloys without containing dendritic tungsten. Cylindrical compacts 15 mm high and 80 mm in diameter were produced from commercial PTS titanium, PChS chromium, PM15TS carbon black, and PFel iron, PniEli nickel, or PCol cobalt powders. Application of a thermal pulse at one base initiated an exothermic reaction, gasless

combustion, which then spontaneously propagated throughout the cylinder volume in the axial direction with a temperature of 2200-2800 K. Hydrostatic pressure was applied after the synthesis reaction wave had reached the other base. Qualitative and quantitative microanalysis of the products in an ISChA-733 apparatus with 15 keV electrons, with pure metals and  $\text{TiC}_{0.95}$  as reference standards, has established the elemental composition and the existence of three phases: I) binary carbide  $(\text{TiCr}_x)\text{C}_y$ , solid solution; II) ternary carbide  $(\text{CrM}_p\text{Ti}_s)\text{C}_t$  ( $M = \text{Fe, Co, Ni}$ ), solid solution, or  $\text{Cr}_3\text{C}_2$  carbide in composites containing more than 8 wt.% Ni; III)  $(\text{Cr, Ti}) + (85-95) \text{ wt.}\% \text{ M alloy}$ . Calculations by the ZAF method of three corrections on the basis of measured intensities of  $\text{K}_\alpha$ -lines in the x-ray spectrum have yielded the concentrations of elements in each phase depending on the fraction of M metal (Fe, Co, Ni) in the powder mixture, those corrections being for the atomic number, for absorption, and for fluorescence. The structure of all the composites consists of round phase I grains with phase II and phase III inclusions in the interstices, the size of phase I grains decreasing as the wt.% M increases. Since most of the composites contain much more refractory phase II than fusible phase III, phase II serves as principal binder for phase I. References 6: 5 Russian, 1 Western (in Russian translation).

2415/12955  
CSO: 1842/51

UDC 669.715:621.745

#### PHASE COMPOSITION AND PHASE CONVERSIONS IN AL-SI ALLOYS QUENCHED FROM THE LIQUID STATE

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian, No 11, Nov 86, pp 5-7

[Article by K. I. Uzlov, V. I. Mazur and V. Z. Kutsova, Dnepropetrovsk Metallurgical Institute]

[Abstract] A study is made of the phase composition of rapidly quenched aluminum-silicon alloys and the specifics of conversion upon decomposition of intermediate metastable phases. The silicon content varied from 6 to 40.6%. Microstructural analysis was performed on sections etched with a 0.5% hydrofluoric acid solution. Crystallization of the alloys was found to be accompanied by formation and subsequent spontaneous decomposition at 273-293 K of metastable intermediate phases. The morphology of the structural components of the rapidly quenched silumins was genetically related to the habitus of the corresponding intermediate phases, the leading phases in the process of growth of eutectic colonies, and to the nature of solid phase conversions upon their decomposition. References 2: both Russian.

6508/12955  
CSO: 1842/61

## INFLUENCE OF HEAT TREATMENT ON THE PROPERTIES OF BOROALUMINUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 11, Nov 86, pp 45-47

[Article by B. A. Arefev and A. V. Rebrov, Metallurgy Institute imeni A. A. Baykov]

[Abstract] Results are presented from a study of the influence of heat treatment on the properties of boroaluminum obtained by rolling in the direction of the fibers. Methods are noted for improving thermal stability by the use of reinforcing fibers with protective coatings. Boron fibers 140  $\mu\text{m}$  in diameter, with and without a coating consisting of a layer of  $\text{B}_4\text{C}$  2  $\mu\text{m}$  thick, were used in a matrix of aluminum alloy AD1. The material obtained was heated at 200-600°C for 1-40 hours, then tensile tested along and across the direction of the fibers, and tested for layer separation strength. Heat treatment primarily caused a decrease in transverse strength with an increase in ductility. The protective properties of the carbide coating on the boron fibers appeared at annealing temperatures of over 550°C. References 5: 4 Russian, 1 Western (in Russian translation).

6508/12955  
CSO: 1842/61

UDC 621.922.025:621.921.34

## STRUCTURE AND PROPERTIES OF DIAMOND-CONTAINING COMPOSITE MATERIAL WITH TUNGSTEN-FREE MATRIX FOR STRAIGHTENING TOOL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 11, Nov 86, pp 47-50

[Article by L. F. Stasyuk, E. D. Kizikov and I. P. Kushtalova, Superhard Materials Institute, Ukrainian Academy of Sciences]

[Abstract] An attempt was made to create a diamond-containing composite material with tungsten-free metal matrix suitable for replacement of natural diamond in the manufacture of tools for straightening grinding disks. Composites were made of Ti-Ni alloys with relatively low melting point, good strength, wear resistance and diamond-holding properties. Synthetic diamonds in the 400/315  $\mu\text{m}$  fraction were used. Introduction of 15-20% TiC to the Ti-Ni matrices was found to decrease wear of the specimens significantly by increasing microhardness. There is a narrow zone of liquid-phase sintering which achieves tight bounding of the matrix to the surfaces of the diamond grains around and slightly above 1450°C. The composite material produced has good wear resistance and uses synthetic diamonds to save tungsten. Its efficiency in use is equal to natural diamond tools. References 4: all Russian.

6508/12955  
CSO: 1842/61

## THE PERCOLATION APPROACH AS A BASIS FOR EXPERIMENTAL RESEARCH ON THE MECHANICAL PROPERTIES OF COMPOSITE MATERIALS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 291, No 4, Dec 86  
(manuscript received 21 Oct 85) pp 850-853

[Article by R. A. Turusov, M. I. Gay, L. I. Manevich, V. G. Oshmyan, E. S. Zelenskiy, Z. P. Sulyayeva and V. I. Sochnev, Physical Chemistry Institute of the USSR Academy of Sciences, Moscow]

[Abstract] The applicability of the concepts and methods of the theory of percolation to the elaboration of the elastic properties of composite materials was subjected to experimental validation by testing the functions of the elasticity moduli of the components. The test specimens were rectangular plates 160 mm long, 60 mm wide and 3 mm thick. They were made by placing a quadratic grid with 4-mm square cells on a rectangular bed of the dimensions to be taken by the specimens, randomly placing various quantities of steel cylinders 4 mm in diameter and 3 mm long upright in a large number of the cells, and then filling the entire matrix with plasticized epoxy resin. Specimens were also made without using the steel cylinder filler in order to obtain data on the modulus of the resin matrix. The resin was allowed to cure at room temperature. The specimens were vertically suspended by an articulated joint. Clamps were used to grasp the ends of the specimens. The ends had no filler, and the edge of the clamps converged on the border of the filled part of the specimens. The load was applied in increments. Load and displacement of the upper and lower boundaries of the filled area were measured. The moduli were isolated using the straight lines on the stress versus deformation curves. All specimens were tested at the same time. Since the resin continued to cure throughout the experiment, it was possible to test a wide range of elasticity moduli (from 10 to 15,000 kg/cm<sup>2</sup>). The results showed that the elastic properties of the composite were affected by the percolation characteristics of its structure, but that the concept of percolation is limited in its ability to explain the mechanisms behind the deformation of the composites. References 10: 3 Russian, 7 Western.

13050/12955  
CSO: 1842/56

UDC 620.197.3

PROTECTION OF Cu-5Ni-1Fe ALLOY AND STEEL WITH INHIBITORS AGAINST AQUEOUS SOLUTION OF HYDROCHLORIC ACID AND HYDRATED CONDENSATE OF LOW-MOLECULAR ACIDS DURING WASHING OF TURBINE CONDENSERS IN THERMAL ELECTRIC AND ATOMIC ELECTRIC POWER PLANTS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 5, Sep-Oct 86 (manuscript received 13 Nov 85) pp 92-95

[Article by N. N. Berezkin, S. S. Kirilyuk and A. K. Mindyuk, Lvov Institute of Medicine, Physical Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences]

[Abstract] A comparative study of 14 commercial inhibitors (including Captax, "Donbass", urotropine) and 12 new special-purpose inhibitors was made for a determination of their effectiveness in protecting turbine condensers made of Cu-5Ni-1Fe alloy tubing and St3 steel parts against corrosion during periodic washing with aqueous solution of HCl and hydrated condensate of low-molecular organic acids in thermal electric and atomic electric power plants. While the commercial inhibitors KhOSP-10 and KhOD-1, especially the KhOD-R modification, were found to be adequate in 5% HCl solution, the new inhibitors UKS-2P and YuTE-1P were found to be extremely effective in up to 97% HCl solutions. They are soluble and do not cause foaming, thus facilitate access to the condenser surfaces while at the same time inhibiting dissolution of copper in hydrated 7% or even 14% condensate of low-molecular acids in the presence of steel. References 3: all Russian.

2415/12955  
CSO: 1842/58

DIRECT METHOD OF MONITORING CORROSION OF NICKEL AND ITS ALLOYS IN TECHNOLOGICAL MEDIA OF  $\text{KNO}_3$  PRODUCTION PLANTS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 5, Sep-Oct 86 (manuscript received 23 Jan 86) pp 95-96

[Article by B. A. Gru, V. S. Novitskiy, G. R. Azhipa and E. E. Pfefer, State Scientific Research Institute of Methanol Production Planning (Gos NII metanolproyekt) Severodonetsk, Voroshilovgrad Oblast]

[Abstract] A direct method is proposed for monitoring corrosion of nickel and its alloys in the technological media of  $\text{KNO}_3$  production plants, these media containing highly aggressive hydrous  $\text{NOCl}$ . Steels with higher than 50% Ni content plus Mo and Cr have adequate corrosion resistance in anhydrous  $\text{NOCl}$ . In an experimental laboratory study plain nickel and three nickel alloys (Ni70MoV, CrNi78Ti, CrNi65MoW) were tested for corrosion resistance at  $-10$ - $(-16)^\circ\text{C}$ , and then at room temperature  $20$ - $25^\circ\text{C}$  for 120-4000 h, by the direct electrochemical method in a glass vessel with two conical working electrodes and a Pt auxiliary one. Polarization curves were plotted with a P-5827M potentiometer, both potentiodynamically, with a voltage sweep at a rate of 1.44 V/h, and potentiostatically, with the voltage raised in 50 mV steps every 3 min. In anhydrous  $\text{NOCl}$  none of the materials corroded at a rate higher than  $0.1 \text{ g}/(\text{m}^2 \cdot \text{h})$  at high anodic potentials, but their corrosion potentials dropped appreciably upon addition of 3%  $\text{H}_2\text{O}$ . It therefore is necessary to monitor humidity of the atmosphere containing  $\text{NOCl}$  for the purpose of corrosion control, which can be done on the basis of the measurable corrosion potential of an indicator electrode. Desiccation of the flue gases by means of nitrogen oxides is considered and being developed as countermeasure. References 2: both Russian.

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## EFFECT OF ENDOGAS WITH HIGH CARBURIZING CAPACITY ON QUALITY OF CASE HARDENING

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 12, Dec 86, pp 2-3

[Article by V. L. Meleshkin and Ye. Ya. Labutina, Scientific Research Institute of Automobile Manufacturing Technology]

[Abstract] Endogas has been found to be an effective case hardening agent when purged not only of water but also of the strong decarburizing agent  $\text{CO}_2$ . The treatment should also include adding  $\text{CH}_4$  to the gas along its flow path. An experimental study was made for the purpose of evaluating the effectiveness of such "dry" endogas in a manufacturing plant. Specimens

of 25CrMnMo steel were tested in flexure and in impact, after having been case hardened in a 2-stage process (930°C for 7.5-9.5 h then at 930-880°C) with "dry" endogas containing 0.01-0.03% CO<sub>2</sub> or with plain endogas containing 0.2% CO<sub>2</sub>. Five parameters were monitored: carbon potential, CO and CO<sub>2</sub> volume fractions, process temperature, and steel alloying index. Evaluation of the test data, including case thickness and microhardness measurements as well as microstructural examination, indicates that use of "dry" endogas has a favorable effect on the case hardening process. Adding CH<sub>4</sub> to the endogas permits lowering the amount of natural gas in the furnace, which also contributes to better carburization of steel. References 1: Russian.

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PROPOSAL TO REDUCE THE NUMBER OF STEEL GRADES

Moscow NTR: PROBLEMY I RESHENIYA in Russian No 23, 1-15 Dec 86, pp 1-2

[Article recorded by A. Zlobinskaya: "Are They Being Taken out of Production?"]

[Text] The draft of an unusual state standard has been developed on the basis of the recommendations of a temporary GKNT [State Committee for Science and Technology of the USSR Council of Ministers] scientific and technical commission on the unification of the list of grades in ferrous metallurgy. It includes more than 600 steels and alloys that should be taken out of production in order to prevent their use in new and modernized machinery.

Its chairman, N. P. Lyakishev, corresponding member of the USSR Academy of Sciences and head of the Central Scientific Research Institute for Ferrous Metallurgy imeni I. P. Bardin, reports on the work of the commission.

"The number of steel grades produced increased 1.5 times during the last 10 years. It would appear that the abundance of steel grades satisfies the demands of the national economy and is advantageous to everyone. But excessive growth of the assortment is frequently against the interests of production and leads to economic losses.

It may be necessary to stockpile excessive quantities of raw materials in order to produce various alloys; who knows, an order for some grade may arrive tomorrow. This complicates the planning of steel production. Constant changes of technology and changeovers to different grades of steel lower productivity and complicate the collection and preparation of scrap.

It is not any easier for the users. How does a designer select a steel he needs at a given moment from 20 steels and alloys having nearly identical properties and uses? If, by mistake, he selects an unsuitable grade, excessive material consumption, design flaws, and other losses are inevitable. Machinebuilders also have a problem. How can one replace even simplest multipurpose parts by other parts if they are made from different steel grades?

Limiting the number of steel grades also means a stricter approach to steel quality. Among similar steels, one can always find one that is best, so

why bother with the other steels. Sometimes the appearance of a new alloyed steel benefits only its inventor; he will put into it some expensive and scarce element in order to make it different in some way from other steels. This is what makes machines and other equipment expensive.

Less, better, and cheaper can be our slogan in carrying out the unification of steels and alloys.

It is not a simple matter to rate each grade according to chemical composition, cost, production volumes, and mechanical properties, particularly after different types of treatments. But even after this laborious effort it is by far not always possible to definitively determine the effectiveness of many steels, for today we may have one kind of raw material reserve, and tomorrow the situation may change because of the opening of a new deposit. Furthermore, the technology of melting and processing steel is constantly developing and improving. This means that a steel grade that is ineffective now may soon become attractive.

We began to improve the list of steels by introducing a set of industry standards that establish a new procedure for putting products into production. It should, as a barrier, hinder the appearance of ineffective steel grades. Eleven working groups that include experts from the Ministry of Ferrous Metallurgy and from the user industries identify grades having similar properties, and evaluate their technical and economic indicators. Recommendations have already been made to eliminate about 300 obsolete steel grades from general use, taking into account industry restrictive lists presented by 13 ministries. We hope that the remaining ministries will also respond, because all industries should be interested in lowering the cost and improving the production of metal, stabilization of production practice, and improvement of metal products.

There is another undesirable source of the birth of new grades. The use and repair of imported machinery frequently require metal grades that we do not have. Metallurgical enterprises are forced to produce small lots of these grades, which brings about losses. We can avoid unjustified expansion of steel grades by coordinating the purchases of machines and equipment with the USSR Ministry of Ferrous Metallurgy.

Many metal-consuming industries create alloys for specific intra-sector uses in their own scientific research institutes. And owing to inadequate communications between the industries, alloy development work is frequently duplicated. Therefore currently a procedure is being adopted according to which technical assignments for the development of new grades should be coordinated with leading institutes of the USSR Ministry of Ferrous Metallurgy. This step will bring closer the interindustry unification of steel and alloy grades.

Ferrous metallurgy is the initiator of a sharp reduction and unification of the types of metallic materials. The USSR Ministry of Nonferrous Metallurgy is beginning similar work."

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## FLAMMABILITY CHARACTERISTICS OF SPONGE IRON POWDER

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in  
Russian No 11, Nov 86 (manuscript received 27 May 86) pp 150-151

[Article by V. N. Brinza and I. V. Turkin, Moscow Steel and Alloys Institute]

[Abstract] For the purpose of fire prevention during transport and storage of sponge iron powder produced by grinding, a study was made concerning the flammability characteristics of this material. According to the All-Union State Standard 12.1.044-84, its flammability threshold concentration is above  $2000 \text{ g/m}^3$  and its flash point is  $175^\circ\text{C}$ . Published data indicate, however, that the flammability threshold concentration of sponge iron dust lies within the  $100\text{-}220 \text{ g/m}^3$  range. This difference is attributable to oxidation during crushing and adsorption of atmospheric moisture, with a subsequently greater tendency to lumping. It therefore is necessary to treat sponge iron powder as a highly flammable material and to categorize it into size fractions, while conforming to the All-Union State Standard 12.1.044-85.

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SHORTCOMINGS IN ORDER FULFILLMENT IN NONFERROUS METALLURGY ENTERPRISES

Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian, 23 Dec 86, p 2

[Article by special correspondent O. Buzuluk: "The Time of "Pushers" is Over"]

[Text] A group of managers from related enterprises came to the Kolchugino Ferrous Metals Processing Plant imeni Ordzhonikidze. In the course of his talk about the experience with fulfilling all customers' orders, M. Temkin, the plant manager, remarked that he had seen the last "pusher" at the plant two years ago. And he added that modernization and widespread use of computers had helped the situation.

Temkin pushed a key, and a monitor screen came to life in front of those gathered. An order (spetsifikatsiya) was selected at random and entered in the computer: several hundred kilograms of complicated structural rolled shapes has to be shipped to a tractor plant in the middle of the calendar quarter. Columns of printed lines appear on the screen: the job has been assigned to such and such shop; the completion and delivery date will be one week ahead of the planned date; the shapes must still be graded. The fate of this lot of structural shapes, as of all other lots, is monitored by computers until it is received by the customer. This will ensure a smooth operation even under the conditions of the state-approval system [gospriyemka], which will be implemented starting from the beginning of next year.

The automated control system, "Zakaz" [order], which controls deliveries in Kolchugino, uses 120 programs that offer not only the possibility of accounting and control but also of evaluating the progress of production and of day-to-day planning production and sales on the basis of optimum variants. For example, if a shop is unable to fill a railroad car for delivery at a given location, the information and computer center transmits the data to other shops, whereupon the car is filled and does not stand idle. The system could work much more efficiently if USSR Gosplan could allocate additional computer terminals to the Kolchugino people.

"We do not have anything like it," said general manager of the Leningrad Krasnyy Vyborzhets association, A. Koshurin. "We rent a computer at the All-Union Scientific Research and Planning Institute for the Aluminum, Magnesium and Electrode Industry, but our landlords rarely allow us to use

it. Of course, accounting and monitoring of deliveries is insufficient for today's requirements."

Unfortunately," continued A. Koshurin, "our production departments merely serve as collectors of information regarding the status of orders within the plant, and they merely state the fact that the planned tasks have not been fulfilled. How can we solve this problem? We hope to establish at our association a computer system based on small SM-series computers, which we shall install this year. Till then we shall perform the paperwork manually."

This is how things stand. And this is at a time when there is an urgent need to introduce large-scale minicomputerization of workplaces and to delegate laborious routine work to computers. As practice shows, computers make it possible to draw up and distribute orders more efficiently. However, thus far orders are processed manually at most of our nonferrous metallurgy enterprises, and this requires the use of workers not only from the supply planning sections but also from other service sections. As a result, miscalculations and errors are unavoidable.

And this has a pronounced effect on the fulfillment of orders. One out of every three enterprises of the USSR Ministry for Nonferrous Metallurgy fail in this regard. Only one-half of the Ministry's subdivisions complete customers' orders fully and on time. These are the Solyzaluminiy, Soyuzpolimetall, Soyuznikel, Soyuzvolfram, and Soyuzsvetmash associations and the Nonferrous Metallurgy Administration of the Armenian SSR. On the other hand, the subdivisions of the Ministry that receive most of the orders lag behind. These are the Soyuzsvetmetobrabotka and Soyuztverdosplav associations and the Nonferrous Metallurgy Administration of the Azerbaydzhan SSR. This in spite of the fact that most of them will change to the state approval system in January.

It should be mentioned for the sake of accuracy that many collectives within these units fulfill their orders with distinction. These are the Kirovsk, Kolchugino, Moscow, and Balkhash nonferrous-metals processing plants, the Kanakerskiy, Kirovabad, and Sumgait aluminum plants, the Baku aluminum-rolling plant, and most of the industry's hard-alloy plants.

But their efforts are offset by negligent producers such as the Yuzhuraltsvetmetobrabotka and Krasnyy Vyborzhets associations, the Mikhaylovsk nonferrous-metals processing plant, and the Zaglikskoye alunite ore administration. The order fulfillment discipline at the Moscow Combine, the Kirovgrad Hard-Alloy Plant, the Svetlovodsk Hard-Alloy Combine, and the Ordzhonikidze pobedit plant is still not up to the requirements of the scientific and technical progress. And even if percentage-wise this figure is small, it forces the state, because of delivery shortfalls, to import brass strip for radiators, polished brass sheets, rolled copper-nickel products for eyeglass frames, thin-wall brass tubing, aluminum foil for the food industry, condenser foil, copper air-conditioning tubing, and hard-alloy articles.

Entirely too much of production capacity in the industry is underutilized. Equipment utilization is still low. The growth of the share of modern technology is slow. There is several times more worn-out equipment than modern equipment in the total equipment inventory. The machine builders do not provide adequate help. Ten years ago, plans were initiated for a new four-stand tandem mill for the Kirovsk Nonferrous Metals Processing Plant. The last planned delivery of equipment is expected to take place in 1½ or 2 years. It took eight years to build a coil-slitting unit for operation in conjunction with this mill. The red tape involved in the building of a continuous annealing line broke all records. Its planning began fifteen years ago, and the customer still has not received it. Because the plants and institutes of the Ministry of the Electrical Equipment Industry and of the Ministry of Heavy and Transport Machine Building have failed to complete their work, the precision rolling mill shop does not have a sufficient thermal capacity.

"How can we talk about the precision of rolled products?!", worries the Kirovsk plant party committee secretary Yu. Sheromov. We get bearings from the Kuybyshev GPZ-9 in which the radial play equals the thickness of the strip that we roll. How can one set up the mill to obtain the desired strip thickness?

The metallurgists themselves are also not blameless. For example, the Krasnyy Vyborzhets Association has failed to install for 20 years a prototype model of a hydraulic press manufactured by Uralmash.

The most painful points are equipment, organizational and other forms of mismanagement, insufficient use of science, and the postponement of the most labor-intensive orders to the end of the month or quarter. The USSR Ministry of Nonferrous Metallurgy is well aware of them, and a great deal of effort is expended at the enterprises in order to cure them. However, thus far these efforts have failed to produce the desired effect. The metallurgists have been slow to increase the production of articles that merit the badge of quality, and at many enterprises the production of these articles has even decreased.

While tightening the deliveries discipline at their own plants, they fail to strengthen their contacts with the subcontractors. With the tacit approval of USSR Gosplan, the customers adjust every third or fourth order. Such a progressive form of supply work as direct long-term economic contacts is not sufficiently developed. The All Union Main Administration for Supply and Sales of Nonferrous Metals [Glavsvetmet] of the USSR Gosplan merely diligently records delivery shortfalls, but does not assume the responsibility for the development of a network of subdepots [podkomplektovochaya baza] capable of completing orders. This would lighten the load on transportation facilities and permit the production of large lots of products for the region.

The lack of timely availability of rolling stock, poor supply to the metallurgists of containers of various sizes, and the rigid requirement that railroad cars must be loaded to "the loading norm" are obvious obstacles to 100-percent fulfillment of orders. A situation arose in which the Northern Railroad,

having plans to transport timber, coal, textiles, and nonferrous rolled products, transports "other loads." The losses are also immeasurable. For failure to supply a car according to plan, a plant can levy a fine in the laughable amount of 5 rubles, whereas the value of the undelivered products is tens of thousands of rubles.

A few months ago, the Politburo of the CPSU Central Committee discussed the question of measures aimed at increasing the responsibility of associations, enterprises, and organizations for the fulfillment of product delivery agreements. The decree adopted by CPSU Central Committee and the USSR Council of Ministers points out the ways of enhancing the observance of plans and agreements and of improving the conditions that ensure rhythmic work.

The slogan "all metal according to orders" should become the rule of the production life of all nonferrous metallurgy enterprises. But for this purpose it is necessary to actively emulate the exemplary experiences obtained at plants such as the Kolchugino Plant. The time of "pushers" is over.

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## STRUCTURE AND MECHANICAL PROPERTIES OF AL5, AL7, AL9 ALLOYS WITH ADMIXTURE OF RARE EARTH METAL

Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 86, pp 8-10

[Article by M. B. Altman, doctor of technical sciences, N. P. Stromskaya, engineer, N. V. Guskova, engineer, and N. I. Prostova, engineer]

[Abstract] The effect of adding yttrium and rare earth metals of the lanthanide group to the aluminum alloys AL5 (Al-Cu-Si), AL7 (Al-Cu), AL9 (Al-Si, 0-0.12% Ti) was studied, the solubility of rare earth metals in aluminum being much lower (0.04-0.05%) than that of yttrium (0.16%). Each alloy, produced from A99 aluminum in an open hearth and containing 0.1-0.2% Fe, was remelted in an electric furnace of 8 kg capacity, whereupon yttrium and four rare earth metals were added to the melt at 740-750°C so as to form in it also a binary Al-r.e.m. alloy containing 12% La, 12% Ce, 20% Pr, 20% Nd respectively as well as 10% or 30% Y. The composite alloys were then refined with  $MnCl_2$  at 720-730°C and cast into molds at 710°C. Cylindrical specimens 12 mm in diameter were heat treated by standard quenching and subsequent aging at 150°C for 3 h or at 175°C for 3 h. Their microstructure was examined before and after each treatment. They were tested mechanically for tensile strength and percentage elongation. The results indicate that 0.01-0.24% Y is beneficial for the alloys AL5 and AL9 and more than 0.1% Y is detrimental for the alloy AL7. While 0.07-0.41% Ce is detrimental for all three alloys cast, quenched, and aged, up to 0.5% Pr or Nd has no effect on the alloys AL5, AL9. The mechanical properties of the alloy AL9 are improved by 0.04-0.33% La, not as much as by 0.01-0.24% Y, but worsened by 0.33-0.9% La. References 2: 1 Russian, 1 Western (in Russian translation).

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## DEPENDENCE OF DENSITY OF CENTRIFUGALLY CAST LS-59-1 BRASS ON MAIN TECHNOLOGICAL PARAMETERS

Moscow LITEYNOYE PROIZVODSTVO in Russian No 6, Jun 86, pp 15-17

[Article by V. I. Osinskiy, candidate of technical sciences and M. V. Solovyev, engineer]

[Abstract] Centrifugal casting of LS 59-1 brass is analyzed, specifically the dependence of density as indicator of product quality on the technological parameters including those of the feed system. Regression analysis of the results of a 3-level 8-factorial experiment has established that the principal influencing parameters are (in the order of decreasing significance): diameter of the feeder ( $x_1 = +0.069$ ), metal temperature and mold temperature combined ( $x_3x_4 = -0.057$ ), length of the riser ( $x_8 = -0.049$ ), mold temperature and mold speed combined ( $x_4x_5 = -0.036$ ). Parameters constituting "noise" but not to be disregarded are: mold temperature alone ( $x_4 = +0.03$ ), number of castings per tier ( $x_7 = +0.021$ ), mold speed alone ( $x_5 = -0.012$ ), distance from axis of rotation to center of casting ( $x_6 = +0.008$ ), metal temperature alone ( $x_3 = -0.008$ ). The destiny of finished castings was found not to depend on the length of rotation time and on the crystallization interval, all tests were therefore run for 300 s. The results can serve as a sound basis for design optimization of the centrifugal casting process. References 1: Russian.

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## STRUCTURE AND PHYSICAL AND CHEMICAL PROPERTIES OF SILUMIN CASTINGS SOLIDIFIED UNDER PRESSURE

Moscow LITEYNOYE PROIZVODSTVO in Russian No 7, Jul 86, pp 8-9

[Article by Candidates of Technical Sciences V. I. Bezpalko and A. I. Batyshev]

[Abstract] A study of the effects of nominal solidification pressure  $p_n$  between 0.1 and 250 MPa, superheat temperature above liquidus  $T_s$  between 50 and 200°C, initial mold temperature  $T_m$  between 290 and 490°K, holding time in the mold prior to the application of pressure  $t_o$  between 4 and 8 seconds, and time under pressure of 25 seconds on the macrostructure and mechanical properties and density of 50-mm diameter, 100-110 mm high castings made of aluminum A7, eutectic alloy AL2, and Al - 6% Si alloy is reported. The macrostructure of pressure castings contains zones of fine,

columnar, and equiaxial crystals. A pressure increase results in grain refinement and attendant improvement of mechanical properties. Three crystal zones exist at  $T_s$  of 50°C, but only columnar crystals remain at  $T_s$  of 200°C. At  $T_m$  of 290-310°K the structure consists entirely of columnar crystals. Equiaxial crystals begin to appear at higher temperatures and become predominant at 420-440°K. Grain coarsening occurs with increasing  $t_0$ ,  $T_s$ , and  $T_m$ . The effects of casting parameters and silicon content on the tensile strength, elongation, area reduction, Brinell hardness and density of castings are represented by statistical regression equations and graphs. References 1: Russian.

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#### EFFECT OF HEAT TREATMENT ON CREEP LIMIT OF COMPLEX VANADIUM ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKhanika MATERIALOV in Russian Vol 22, No 5, Sep-Oct 86 (manuscript received 4 May 84) pp 48-52

[Article by Ye. M. Lyutyy, V. I. Kalyandruk and M. A. Peresichanskaya, Physical Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, Lvov]

[Abstract] Two complex vanadium alloys, with Nb and Zr, were tested for the creep limit after combined solution-dispersion hardening. Specimens of the two alloys, VZrCNb-1 (0.1% C, 10.5% Nb, 1.1% Zr) and VZrCNb-2 (0.17% C, 10.5% Nb, 1.9% Zr), were heat treated by annealing for 1 h, some at 1473 K and some at 1873 K, so as to produce structures with different grain sizes. They were then hardened at temperatures of 1173 K and 1273 K under vacuum. Tensile strength and plasticity were measured in a six-point radial machine in an atmosphere of spectroscopically pure argon; creep strength was measured in a multipoint machine under a vacuum of  $1.3 \cdot 10^{-3}$  Pa. Both tests were performed at increasingly higher temperatures from 273 K up to 1173 K and 1273 K. Discontinuous yielding was found to begin at 573 K and subsequent brief stress relaxation before further buildup of stress was found to cease at 873 K. For comparison, plain vanadium and the simple dispersion-hardened VZrC vanadium alloy with Zr only in were tested in an analogous manner. The results indicate that the creep limit of those vanadium alloys depends on the volume fraction of the hardening phase, a higher ZrC content (VZrCNb-2) lowering the creep limit at 1173 K, and that high-temperature heat treatment raises the creep limit at both 1173 K and 1273 K. References 14: 7 Russian, 7 Western (3 in Russian translation).

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## EFFECT OF ALLOYING ON PERFORMANCE OF VANADIUM AND ITS ALLOYS

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 5,  
Sep-Oct 86 (manuscript received 23 Jul 85) pp 55-59

[Article by V. V. Shirokov, Physical Mechanical Institute imeni G. V. Karpenko, UkSSR Academy of Sciences, Lvov]

[Abstract] Alloying of vanadium and thermochemical treatment of its alloys as well as of plain vanadium were studied for the effects on their mechanical strength and heat resistance. For that purpose 1 mm thick and 3 mm wide strips of plain vanadium VM-2, V-W alloys (5-15% W), V-Ti alloys (5-20% Ti), V-Nb alloys (5-20% Nb), one V-Zr alloy (0.32% C, 3% Zr), and V-Zr-Nb alloys (0.3-0.4% C, 10-15% Nb, 2.6-3.0% Zr) were hardened by appropriate heat treatment in accordance with the dispersion-hardenability of the VZrC alloy, the solution-hardenability of all the other binary alloys and the solution-dispersion-hardenability of the VZrCNb alloys. Specimens were held for 100-5000 h at temperatures of 1073K and at 1173 K under oil-less vacuum of the order of  $10^{-3}$  Pa in 12-point radial apparatus under various stress levels. Specimens held in He with O<sub>2</sub>, N<sub>2</sub>, H<sub>2</sub>, CO, CO<sub>2</sub> impurities at 1023 K and at 1073 K were then tested for tensile strength and creep strength at temperatures up to and above 873 K and were also examined for changes in structure and phase composition. The results indicate that these vanadium alloys as well as plain vanadium are suitable for service at high temperatures in inert atmospheres, but their oxidation can be effectively prevented only by protective coating. References 8: all Russian.

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UDC 537.326

## TEMPERATURE AND STRAIN DEPENDENCE OF THERMOELECTRIC PROPERTIES OF MOLYBDENUM AND EFFECT OF IMPURITIES

Kiev FIZIKO-KHIMICHESKAYA MEKHANIKA MATERIALOV in Russian Vol 22, No 5,  
Sep-Oct 86 (manuscript received 13 Nov 85) pp 59-63

[Article by B. I. Stadnik, I. P. Kuritnykh, V. V. Popovich and P. R. Gamula, Special Design Bureau for Microelectronics and Instrument Making, Lvov]

[Abstract] An experimental study of polycrystalline and pseudomonocrystalline molybdenum thermocouple wires was made, of concern being the composite temperature and stress dependence of their thermal e.m.f. over the respective 300-2300 K and 0-500 MPa ranges as well as the effect of impurities (O<sub>2</sub>, Na, K). Measurements were made not conventionally on wires heated at one end but by means of two thermocouples: one with a specimen between two VR5 branches and one with a specimen between two VR20 branches. The thermal

e.m.f. sought was then calculated relative to the material of VR5 or VR20 branches, without the need to measure small differences between high absolute temperatures. Three combinations of impurities were monitored, 0.022% O<sub>2</sub> + 0.045% Na + 0.0039% K, 0.015% O<sub>2</sub> + 0.03% Na + 0.0026% K, 0.01% O<sub>2</sub> + 0.015% Na + 0.0013% K, and the wires with each impurity content were drawn to 7.8%, 15.4%, 26% reduction of diameter. The thermal e.m.f. was found to peak at some temperature dependent on the impurity content and the degree of plastic deformation. References 12: all Russian.

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UDC 536.424+531.32

# THE EFFECT OF A UNIAXIAL LOAD ON THE ELASTIC PROPERTIES OF ALLOYS UNDERGOING MARTENSITE TRANSFORMATION

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 291, No 4, Dec 86  
(manuscript received 17 Oct 85) pp 847-849

[Article by K. K. Zhaylobayev, V. G. Serebryakov and E. I. Estrin, Physical Metallurgy and Metal Physics Institute of the I. P. Bardin Central Scientific Research Ferrous Metallurgy Institute, Moscow]

[Abstract] The effect of a uniaxial load on the elasticity constants of alloys that undergo martensite transformation was studied. Single crystals of the following alloys were studied: Fe -- 32% Ni, Fe -- 11.6% Ni -- 5.2% Mn -- 0.5% C, Co -- 32.5% Ni, and Cu -- 14.3% Al -- 5.8% Ni. The martensite points were 200, 210, 118, and 230 K, respectively. Monocrystalline specimens 10 x 10 x 10 mm were compressed along the crystallographic lines [100] and [110] on an Fu-1000e testing machine. The elasticity constant was measured using ultrasound frequency of about 4 MHz. The temperature of the specimen was controlled by a copper cooling device equipped with a furnace. The temperature could be varied from room temperature to 100 K and was measured by a copper Constantan thermocoupling with its junction compressed against the heart of the specimen, which was thermally insulated by a plastic foam jacket. The elasticity constant as a function of temperature, given a fixed uniaxial load, and the elasticity constant as a function of uniaxial load magnitude applied at a fixed temperature were studied. The test results showed that a uniaxial load that does not exceed the elasticity limit does not lead to a significant decrease in the rigidity of the crystalline lattice. References 10: 1 Russian, 9 Western.

13050/12955  
CSO: 1842/56

# CHEMISTRY PRODUCTION GOALS FOR 12TH FIVE-YEAR PLAN

Moscow IZVESTIYA in Russian 9 Jun 86 p 2

[Article by V. Sukhachevskiy: "Chemistry and the Five-Year Plan: USSR Supreme Soviet Before the Session"; passages rendered in capital letters are printed in boldface in source]

[Text] As the implementation of the chemicalization program of the national economy proceeds, what have we done successfully and what advances must we make in the 12th five-year plan? These questions, important for our domestic economy, were examined at the meeting of the Preparatory Commission on the Forest Chemistry Complex which was formed by the Permanent Commissions of the USSR Supreme Soviet Chambers. The following presented reports and information: Deputy Chairman of the USSR Gosplan A. Lukashov, Deputy Chief of the USSR Gosplan Department of the Oil and Gas Industry D. Kondakov, Chief of the Chemistry Department of the USSR Committee on Science and Technology V. Novoseltsev, Minister of the Chemical Industry V. Listov, Minister of the USSR Oil Refining and Petrochemical Industry N. Lemayev, First Deputy Minister of Mineral Fertilizer Production A. Kochetkov, USSR Gosplan Deputy Chairman G. Merkulov, and Deputies M. Paryshkura and N. Nadson.

At the meeting, it was pointed out that development of the chemical complex sectors is proceeding at rapid rates. Such a tendency should be maintained in the 12th five-year plan as well. For example, it is planned that the production of resins and plastics will be increased by more than 140 percent, chemical agents for plant protection by 135 percent, fibers and filaments by 133 percent, and goods for cultural and personal services as well as household use by more than 146 percent.

It is also planned that a substantial part of this increased production will be through technical retooling and modernization of enterprises, and assimilation of new techniques and technological processes.

The economic managers, specialists and deputies who addressed the meeting devoted considerable attention to the oil refining industry. This was mainly because this sector was unable to cope with its goals

for a number of important indicators in the 11th five-year plan. Specifically, construction of projects for the production of oils and additives and of petroleum coke calcination units have been dragged out, leading to serious intersector and intrasector disproportions.

Expenditures for labor, power and material resources are still high in the sector enterprises. Thus, it was pointed out at the meeting that the USSR Ministry of the Oil Refining and Petrochemical Industry and its contractor organizations are faced in the present five-year plan with a considerable amount of work in eliminating the negative features of sector development.

A five percent increase in oil refining volume is planned for 1990 compared to 1985. This will be achieved through increased extraction and development of deposits in the Caspian lowlands and Western Kazakhstan and in the Orenburg and Astrakhan Oblasts.

The draft plan provides for an increase in motor fuel output by more than 12 percent. The production of motor vehicle gasoline and diesel fuel is growing.

Participants at the meeting focused considerable attention on problems relating to the acceleration of scientific-technical progress in sectors of the chemical complex. And this is as it should be. For example, the Ministry of the Chemical Industry has increased the output of building materials six-fold and has brought it up to 55 thousand tons a year. We can sort of talk about achievements. However, if we compare our indicators with the achievements of the leading capitalistic countries, then we will see that there is nothing to be happy about so far.

The percentage of synthetic fibers and filaments in the total volume of chemical fiber production is to increase from 55.6 percent in 1985 to 65 percent by the end of the current five-year plan. And, again let us compare: the world level is 88.5 percent. In short, we are still far behind. It is sufficient to say that today in five (out of eight) indicators for the technical level of chemical complex production we are inferior to the developed western countries.

Many other figures were heard at the meeting that spoke better than any kind of words about the importance of technical progress. Thus, putting the production of modern chemical building materials into operation will enable us to save more than one million tons of steel and nonferrous metals. The economic effect--1.5 billion rubles! The output and use of new types of membranes in caustic soda production provide for a saving of approximately one million tons of fuel; this means a saving of 800 million rubles a year. The use of new chemical agents for plant protection will reduce grain losses by two million tons.

Last year, a number of ministers from the chemical complex were criticized when the draft plan for 1986 was examined at the meeting of

the Preparatory Commission. As it turned out, specific conclusions were drawn from the criticism. Thus, the Ministry of Mineral Fertilizer Production included a plan to make new capacities operational for ten thousand tons of polycarbonate at the Ufa chemical industry plant. Construction of an enterprise for an annual output of 700 thousand tons of sulfuric acid is also planned.

Minister of the Chemical Industry V. Listov emphasized in particular that all increase of production output will be attained through increased labor productivity in the sector.

The collectives of the oil refining and petrochemical industry have the same type of goal. An extensive program for the use of secondary resources has also been worked out in this sector. There are many reserves here. Let us consider the following problem. Today, only 20 percent of the worn tires are reprocessed and the rest are burned.

"HOW LONG WILL SUCH WASTEFULNESS CONTINUE TO FLOURISH?"

This question, heard at the meeting, was posed by the deputies and was answered by Minister of the USSR Oil Refining and Petrochemical Industry N. Lemayev as follows:

"By 1990 we plan to bring the reprocessing of worn tires up to 65 percent and by the end of this century to 100 percent. The use of secondary resources in this five-year plan will enable us to effect a saving of 340 thousand tons of rubber, 672 thousand tons of lubricating oils and 334 thousand tons of sulfuric acid."

QUESTION: How successfully is the construction of projects for the heavy refining of petroleum being conducted?

N. LEMAYEV: "The minister of the chemical industry has already spoken here of the slow use of capital investments. We are approximately in the same position. About a billion rubles have not been used in the 11th five-year plan. Sort of a change has now begun to show, however, the situation cannot be considered satisfactory: 22 million rubles have not been used in four months. The builders must draw the necessary conclusions."

In his speech Deputy N. Nadson was critical:

"The inadequate efficiency of capital investments can be seen in our kolkhoz as an example. Assuming that during the last two five-year plans the fixed capital of the farm has almost doubled, then growth of the production volumes constituted only 40 percent. What are the reasons for this? The main reason is that the productivity of grain crops, potatoes and vegetables rises slowly. And, this is so because the requirements for mineral fertilizers and plant protection have not been completely satisfied. We receive only half of what is needed."

"There is also a lack of machines needed for intensive technologies. There is a shortage of sprayers and the equipment for introducing liquid fertilizers into the soil is unsatisfactory. I think the deputies will support me when I say the following: the advances that the workers of the Ministry of Fertilizers have planned must be considered as being not high enough. Urgent measures must be taken to reduce the time periods for putting new capacities into operation, to improve the use of operating capacities, and to maximally increase the production of mineral fertilizers and chemical agents for plant protection..."

The Preparatory Commission has worked out comments and proposals that will be considered when the Permanent Commissions of the USSR Supreme Soviet Chambers for the State Plan of USSR Economic and Social Development for 1986-1990 prepare their conclusions.

12525

CSO: 1842/216

CREATION OF DYNAMIC HEAT FIELD IN SURFACE LAYERS OF POLYPHENYLENE OXIDE  
PRODUCTS BY INFRARED LASER RADIATION

Riga MEKHANIKA KOMPOZITNYKH MATERIALOV in Russian No 5, Sep-Oct 86  
(manuscript received 14 Apr 86) pp 791-794

[Article by V. V. Korshak, L. N. Nikitin, E. Ye. Said-Galiyev and I. G. Merinov, Elementoorganic Compounds Institute imeni A. N. Nesmeyanov, USSR Academy of Sciences, Moscow; Moscow Engineering Physics Institute]

[Abstract] Continuing studies begun in a previous work, this article shows the possibility of calculating temperature fields through the depth of a product of poly-2-6-dimethyl-1,4 phenylene oxide (PPO) upon irradiation by a CO<sub>2</sub> laser in a quasi-pulsed mode. Calculation of the temperature fields at various depths is a problem of determining the boundaries of temperature areas after absorption of laser energy by the surface layers of the specimen. Equations are presented for calculation of the temperature at various depths and on the surface of the product. Temperature distribution graphs through the thickness of the product are presented. The temperature field gradient through the thickness of the product causes chemical changes to the surface layers of PPO, causing an increase in microhardness. References 8: 7 Russian, 1 Western.

6508/12955  
CSO: 1842/50

## DESIGN OF OPTICAL LUMINAIRE, REPORT 3: STRESSED-STRAINED STATE AND STRENGTH OF PLANE GLASS ELEMENT

Kiev PROBLEMY PROCHNOSTI in Russian No 11, Nov 86 (manuscript received 10 Nov 84) pp 97-101

[Article by I. I. Dyachkov, A. L. Kvitka, Yu. V. Komyagin and Yu. B. Gnuchiy, Strength Problems Institute, UkSSR Academy of Sciences]

[Abstract] A plane optical luminaire is being designed on the basis of both computer and laboratory experiments. Numerical analysis by computer has yielded eight different possible solutions to the engineering design problem. Laboratory experiments have yielded data on the load capacity of those structures under external hydrostatic and impact loads. The structures, according to design specifications, consisted of flat disks of K8 silicate glass or KV quartz glass in frames made of 40Cr steel (Rockwell C hardness 28-32), VT1-0 titanium alloy, or polymethyl methacrylate (with or without rubber). Disks of three different diameters (76 mm, 39 mm, 35 mm) with four different thickness-to-diameter ratios (0.37, 0.46, 0.72, 0.80) were progressively ground with a diamond wheel and then polished to a fine surface finish of not more than  $R_z = 0.05 \mu\text{m}$  roughness, with 0.05 mm tolerance on the diameter and 0.045 mm tolerance on the thickness. They were then mounted in frames either directly or with adhesive paste, an organic compound such as epoxy or metallizing paste containing fine-disperse  $\text{TiH}_4$  powder. The test results and the results of theoretical stress-strain analysis agree in indicating a low strength in all cases and thus an inadequacy of these particular designs. References 6: all Russian.

2415/12955

CSO: 1842/44

UDC 537.311.33

RELAXATIONAL ISOTHERMAL EPITAXY OF  $\text{Ga}_x\text{In}_{1-x}\text{P}/\text{GaAs}$  FROM LIQUID PHASE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian Vol 22, No 11, Nov 86 (manuscript received 11 Feb 85) pp 1773-1777

[Article by V. V. Kuznetsov, P. P. Moskvina, Ya. Olkhovik and V. S. Sorokin, Leningrad Electrical Engineering Institute imeni V. I. Ulyanov (Lenin)]

[Abstract] An experimental study was made concerning relaxational isothermal epitaxy of  $\text{Ga}_x\text{In}_{1-x}\text{P}$  solid solutions from the liquid phase on  $\text{GaAs}(111)\text{A}$  substrates. The liquid phase was produced by dissolution of InP in In for 30 min, supersaturation being achieved by dissolution of the  $\text{GaP}(111)\text{A}$  substrate in the In-P solution-melt for 15 min. Epitaxy was then effected

at a temperature of  $1073 \pm 0.25$  K in a horizontal quartz reactor with the use of a graphite holder, in a hydrogen stream flowing at a rate of 5 l/h. The liquid phase in the resulting Ga-In-P system was at the same temperature deposited on the GaAs(111)A substrate for precipitation and growth of solid  $\text{Ga}_x\text{In}_{1-x}\text{P}$  layers, a most critical factor in this process being the proper crystallographic orientation of both substrates. The epitaxial layers were examined for chemical composition, according to Vegard's law, their thickness being measured under a Polam P-312 microscope after etching for 15 s at room temperature with a  $\text{KOH}:\text{K}_3\text{Fe}(\text{CN})_6:\text{H}_2\text{O} = 12:8:100$  solution revealing the interphase boundaries. A theoretical analysis of the results is based on the equations of mass balance during dissolution and the kinetics of diffusional mass transfer during mixing, assumed to be complete with high probability of free convection and coherent interlinkage of the solid phases. References 17: 9 Russian, 8 Western.

2415/12955  
CSO: 1842/51

UDC 539.238

# ANOMALIES IN TEMPERATURE DEPENDENCE OF EPITAXIAL GROWTH RATE OF GaAs IN $\text{Ga}(\text{CH}_3)_3\text{-AsH}_3\text{-H}_2$ SYSTEM

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian  
Vol 22, No 11, Nov 86 (manuscript received 27 Feb 85) pp 1778-1780

[Article by I. A. Frolov, A. V. Lukichev, A. M. Tomchinskiy, V. Ye. Averyanov and A. V. Baryshev, Gorkiy State Pedagogical Institute imeni M. Gorkiy]

[Abstract] The temperature dependence of the epitaxial growth rate of GaAs in the  $\text{Ga}(\text{CH}_3)_3\text{-AsH}_3\text{-H}_2$  system is analyzed on the basis of known semi-empirical relations applicable to the rotating-disk technology, assuming an analogy between diffusion of  $[-\text{GaAs}-]$  clusters and Brownian motion, with the aid of statistically analyzed experimental data pertaining to the MOCVD (metal-organic chemical vapor deposition) process. Calculations covering the 770-1120 temperature range indicate a peak of the epitaxial growth rate within the 890-920 K temperature interval followed by a dip and another peak above 970 K. Infrared absorption spectra have revealed a determining role of complete decomposition  $\text{Ga}(\text{CH}_3)_3 + \frac{3}{2}\text{H}_2 \rightarrow \text{Ga} + 3\text{CH}_4$  above 850 K and decomposition  $\text{AsH}_3 \rightarrow \frac{1}{4}\text{As}_4 + \frac{3}{2}\text{H}_2$  above 920 K, the latter reaction being completed above 1020 K. Addition of  $\text{Ga}(\text{CH}_3)_3$  to an  $\text{AsH}_3 + \text{H}_2$  mixture below 870 K lowers appreciably the  $\text{AsH}_3$  concentration by way of the  $\text{AsH}_3 + \text{Ga}(\text{CH}_3)_3 + \text{H}_2 \rightarrow [-\text{GaAs}-]_n$  reaction. References 8: 5 Russian, 3 Western.

2415/12955  
CSO: 1842/49

## PREDICTING PHASE COMPOSITION OF TRANSITION LAYERS FORMED WITHIN Ni-GaAs INTERFACE

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian  
Vol 22, No 11, Nov 86 (manuscript received 23 Jan 85) pp 1781-1785

[Article by N. A. Testova, A. N. Golubenko, G. A. Kokovin and S. V. Sysoyev,  
Inorganic Chemistry Institute, Siberian Department, USSR Academy of Sciences]

[Abstract] The problem of predicting the composition of transition layers formed within the Ni-GaAs interface in Schottky-barrier diodes during heat treatment is studied for purposes of technological quality control, particularly with regard to the electrical characteristics of these diodes. The problem reduces to selection of the appropriate ternary Ni-Ga-As phase diagram from those constructed on the basis of available experimental and theoretical data pertaining to the two binary systems Ni-Ga and Ni-As. This includes the thermodynamic properties of all 11 possible solid-state binary compounds ( $\text{NiAs}_2$ ,  $\text{NiAs}$ ,  $\text{Ni}_{11}\text{As}_5$ ,  $\text{Ni}_5\text{As}_2$ ;  $\text{Ni}_3\text{Ga}$ ,  $\text{Ni}_2\text{Ga}$ ,  $\text{Ni}_3\text{Ga}_2$ ,  $\text{NiGa}$ ,  $\text{Ni}_3\text{Ga}_4$ ,  $\text{Ni}_2\text{Ga}$ ,  $\text{NiGa}_4$ ) in addition to those of the GaAs compound. They have been constructed by the triangulation method for conditions corresponding to room temperature (298 K) and atmospheric pressure ( $1.01 \cdot 10^5$  Pa), assuming that all these binary compounds as well as the three elements alone have narrow ranges of homogeneity and that the change of entropy  $\Delta S^0$  in most solid-state reactions is near zero. Since no data on  $\Delta S$  for 9 of the 12 compounds are available, the possibility of existence of those compounds is based only on the known change of enthalpy  $\Delta H_{298}^0$  in corresponding reactions. The ternary compound  $\text{Ni}_2\text{GaAs}$  is excluded from consideration, inasmuch as it is now known not to form at room temperature. Without it there are six possible ternary phase diagrams; there would be up to 12 if that compound were found to form at room temperature. The final selection of phase diagram is made on the basis of supplemental data provided by special experiments with annealing of Ni + GaAs mixtures ( $\text{Ni:GaAs} = 0.104, 0.417, 0.560, 0.889$ ) under vacuum, with Ni powder produced by reduction of  $\text{NiO}$  by hydrogen at 873 K and GaAs single crystals available at the semiconductor-grade purity level. In order to now predict the composition of the transition layer, for technological purposes, it is necessary to also know the mechanism of mass transfer and particularly the rates of Ni, Ga, As diffusion by whatever mechanism during formation of that layer, these diffusion rates not being subject to thermodynamic constraints. The limiting situations considered are: 1) diffusion of As from GaAs into Ni only; 2) diffusion of Ga from GaAs into Ni only; 3) diffusion of Ni into GaAs only without migration of Ga and As atoms into Ni. The composition of the transition layer is readily determined for these three cases. References 19: 7 Russian, 12 Western (3 in Russian translation).

2415/12955

CSO: 1842/51

ADHESION AND STRESSED STATE OF  $\text{CdGa}_2\text{Se}_4$  FILMS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian  
Vol 22, No 11, Nov 86 (manuscript received 22 Jan 85) pp 1804-1807

[Article by V. V. Onopko, I. E. Kacher, N. I. Dovgoshey, M. Yu. Rigan and  
V. A. Kobal, Uzhgorod State University]

[Abstract] In a study of  $\text{AIII B}_2 \text{III C}_4 \text{VI}$ -compound films, the dependence of their adhesion strength and internal macrostresses on the energy content for vapor molecules, which characterizes the deposition process, has been established for  $\text{CdGa}_2\text{Se}_4$  condensate films deposited by the laser-beam evaporation process on plates of K8 optical glass, NaCl crystal, and KDP crystal. Polycrystalline  $\text{CdGa}_2\text{Se}_4$  for the experiment was synthesized from extra-pure ingredients, after they had been distilled under vacuum, zone refined, and treated with special solvents. Evaporation was effected by means of a laser either with free emission of pulses of up to 0.3 J energy and 100  $\mu\text{s}$  duration, or with emission of giant pulses of up to 0.1 J energy and 20 ns duration, and the use of a thermal shield in each case. The adhesion strength was measured by the method of normal pull and the internal stresses were measured with strain gages as well as by the optical method. Films, built up to 0.2-0.5  $\mu\text{m}$  thickness, were cyclically annealed at temperatures up to 510 K in an oxygen atmosphere for stress relief. The irreversibility of the stress-temperature curves indicates occurrence of phase transformation in the process, including transition from amorphous to crystalline state and possibly surface oxidation. The internal stresses were also found to decrease with increasing film thickness, much more appreciably as the substrate temperature dropped. Maximum adhesion strength was obtained by treatment with giant laser pulses, adhesion to a KDP substrate being strongest. The adhesion strength, accordingly, increases with increasing velocity and thus energy of vapor molecules as well as with higher substrate temperature, an increase of the substrate temperature being equivalent to an increase of their velocity. Use of a reflecting thermal shield was found to lower the adhesion strength, evidently because of a resulting larger low-velocity fraction of vapor molecules, an effect of thermal evaporation, and also owing to the effect of radiative heating on the substrate material. References 10: all Russian.

2415/12955

CSO: 1842/51

## PROPERTIES OF PbSe-GeSe SYSTEM SPECIMENS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian  
Vol 22, No 11, Nov 86 (manuscript received 18 Feb 85) pp 1808-1811

[Article by Ya. K. Kerimov, Yu. V. Andreyev, Ye. N. Laberko and N. I. Budim]

[Abstract] Properties of the PbSe-GeSe system of solid solutions for production of film photoresistors were studied in an experiment with polycrystalline ingot and layer specimens. These had been produced from 99.999 wt.% Pb, Ge, Se by smelting PbSe + (0-37) mol.% GeSe doses in quartz containers under vacuum and quenching the  $Pb_{1-x}Ge_xSe$  products in water. Ingots were pulverized and annealed at a temperature of 500°C under vacuum for 8-10 h. Phase analysis in a DRON-2.0 x-ray diffractometer with  $CuK_{\alpha}$ -radiation source and quantitative x-ray spectral microanalysis have yielded the concentration dependence of the lattice parameter  $a$  over the 0-36 mol.% GeSe range, which deviates from Vegard's law in the direction of larger parameter values, also the concentration dependence of the dark resistance over the  $x = 0-0.12$  range at temperatures of the substrate ranging from -30°C to 60°C and the temperature dependence of the dark resistance over the 77-333 K range. The results indicate the solubility limits for GeSe in PbSe, the limit in polycrystalline layers grown under nonequilibrium conditions being approximately 10 mol.% GeSe. References 5: 3 Russian, 2 Western.

2415/12955

CSO: 1842/51

UDC 541.133.1:546.623'31

ELECTRICAL PROPERTIES OF  $Na_2O \cdot 6Al_2O_3 - Ag_2O \cdot 6Al_2O_3$  SOLID SOLUTIONS

Moscow IZVESTIYA AKADEMII NAUK SSSR: NEORGANICHESKIYE MATERIALY in Russian  
Vol 22, No 11, Nov 86 (manuscript received 22 Jan 85) pp 1854-1856

[Article by A. I. Barkovskiy, N. F. Volkova, A. R. Kaul and Yu. L. Tretyakov, Moscow State University imeni M. V. Lomonosov]

[Abstract] A study of  $(Ag_2O)_x (Na_2O)_{1-x} \cdot 6Al_2O_3$  solid solutions was made for the purpose of determining the frequency dependence of their electrical resistivity over the  $10^3-10^6$  Hz range and the concentration dependence of their electrical conductivity over the entire  $x = 0-1.0$  range. Measurements were made at a temperature of 467°C, the ceramics having been produced by sintering at 1650°C, without and with 0.5 mol.%  $Y_2O_3$  added to the  $\beta-Al_2O_3$  phase for the purpose of increasing the intergranular electrical capacitance and thus improving the resistance resolution. The frequency characteristic of electrical resistivity was found to flatten and the electrical resistivity to decrease throughout the entire frequency range with decreasing  $Ag_2O$

concentration. The lowest electrical conductivity was found to have the solid solution with  $\alpha = 0.65-0.68$ , that of pure  $\text{Na}_2\text{O} \cdot 0.6\text{Al}_2\text{O}_3$  being highest and that of pure  $\text{Ag}_2\text{O} \cdot \text{Al}_2\text{O}_3$  being much lower but above the minimum. The results confirm that  $\text{Y}_2\text{O}_3$  does not diffuse into the  $\beta\text{-Al}_2\text{O}_3$  phase but forms with it a binary system which includes the  $\text{Y}_3\text{Al}_5\text{O}_{12}$  compound. References 9: 2 Russian, 7 Western.

2415/12955  
CSO: 1842/51

UDC 621.315.592

#### THE CONDUCTIVITY OF SINTERED DIAMOND POWDERS

Kiev SVERKHTVERDYIE MATERIALY in Russian No 6, Nov-Dec 86 (manuscript received 5 May 85) pp 3-7

[Article by G. A. Sokolina, S. V. Bantsekov, D. V. Fedoseyev, L. F. Afanasyeva and L. Z. Ponizovskiy, Physical Chemistry and High Pressure Physics Institute, USSR Academy of Sciences, Moscow and Troitsk]

[Abstract] The effect of time and temperature on the conductivity of diamond ceramic materials was studied. ASM 40/28 synthetic diamond powder was sintered in graphite containers under a pressure of about 70 k-bars at temperatures ranging from 900° to 2000°C. The specimens obtained were 6 mm in diameter and 4 mm high. The graphite on the specimens was removed in the air plasma of a glow discharge. Platinum was applied by cathode sputtering to the faces of the specimens to make the ohmic contacts. Conductivity was measured with an electrometric amplifier with a range of  $10^{-11}$  to  $10^{-5}$  amperes. Conductivity as a function of temperature was measured at room temperature in a specialized vacuum apparatus. Regardless of sintering temperature, conductivity as a function of time, measured at room temperature, sharply increased within the first five minutes and then leveled off, with conductivity increasing only slightly. As a function of temperature, the conductivity of specimens sintered for 30 seconds increased by eight orders of magnitude between 900° and 2000°C, with an especially sharp increase occurring between 900° and 1700°C. The energy of conductivity activation changed simultaneously with conductivity as the temperature was increased and was inversely related to conductivity. Increased conductivity was attributed to low-ohm graphite islets that formed on the surfaces of the high-ohm diamond grains not in contact with one another. Here, the localized compressive forces were smaller than where the grain surfaces came in contact with each other. The current carriers travelled from islet to islet in a process known as islet conductance. References 6: all Russian.

13050/12955  
CSO: 1842/48

## AN INVESTIGATION OF THE INFRARED EMISSION SPECTRA OF CARBON CONDENSATES

Kiev SVERKHTVERDYIE MATERIALY in Russian No 6, Nov-Dec 86 (manuscript received 18 Jun 85) pp 7-12

[Article by V. Ye. Strelnitskiy, A. I. Timoshenko, L. A. Gravel and Yu. B. Novikov, Kharkov Physical Technical Institute and the State Optics Institute, Leningrad]

[Abstract] The infra-red spectra of quasi-amorphous carbon condensates were studied to determine the nature of the interatomic bonds in the materials. The condensates were obtained by one of three methods: precipitation of the heat flows from atomic carbon generated by the thermal volatilization of graphite (these are called thermal condensates); the precipitation of a vacuum arc carbon plasma separated from the macroparticles and neutral atoms (diamond-like condensates); and the formation of a film of hydrogenated amorphous carbon using a method described in an earlier work. The thickness of the specimens ranged from 20 nanometers to 5 to 10 micrometers. Fresh salt chips or polished copper were used as the substrates. Absorptivity was calculated from the standard formula. Of two conventionally established bands of infrared spectra, the one between  $3400\text{--}2500\text{ cm}^{-1}$  (3 to 4  $\mu\text{m}$ ), which characterizes the bond-stretching vibrations of the CH, OH, and NH groups was used, as it is the most reliable. In the thin diamond-like film, single tetrahedral carbon-hydrogen bonds predominated. There were no twin bonds and an insignificant number of triple bonds. With an increase in film thickness, unsaturated double and triple bonds formed. In the thin thermal films, all three types of bonds were present, with the unsaturated double and triple bonds predominating. As film thickness increased, the trigonal bonds became the primary type of bond. The bands generated by the hydrogenated carbon films were quite indistinct, but were consistent with a carbon matrix with twin and tetrahedral bonds. Emission infra-red spectroscopy can be used to identify the types of interatomic bonds in carbon condensates. References 15: 9 Russian, 6 Western (3 in Russian translation).

13050/12955

CSO: 1842/48

## THE MECHANICAL PROPERTIES OF CRYSTALS IN COMPOUNDS OF THE AL-B-C SYSTEM

Kiev SVERKHTVERDYIE MATERIALY in Russian No 6, Nov-Dec 86 (manuscript received 22 Aug 85) pp 12-18

[Article by S. N. Dub, T. A. Prikhna and O. N. Ilnitskaya, Superhard Materials Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] The microhardness, cracking resistance, and static compressive strength of crystals in compounds of the Al-B-C system were studied. Crystals from the  $\alpha$ -AlB<sub>12</sub>,  $\gamma$ -AlB<sub>12</sub>, Al<sub>3</sub>C<sub>2</sub>B<sub>48</sub>, and AlC<sub>4</sub>B<sub>24</sub> systems were selected as specimens. The compounds were synthesized from a high-temperature aluminum melt at 1200° to 1750°C. The microhardness and cracking resistance of these crystals was compared with the microhardness and cracking resistance of single  $\alpha$ -Al<sub>2</sub>O<sub>3</sub> single crystals. Static compressive strength was measured in accordance with GOST 9206-80. Microhardness and cracking resistance were measured on a PMT-3 microhardness tester with Vickers and Knoop indentors at loads of 0.49 to 4.91 N. Each crystal sustained 5 to 8 indentations, and the results from 5 to 8 crystals were averaged. The size of the indentations and the length of the cracks were measured on an NU-2E microscope, utilizing phase contrasting, and were magnified 750 to 1000 times. Fracture toughness was used as the criterion for cracking resistance and was calculated from the length of the radial cracks issuing from the angles of the Vickers indentations. In order of increasing hardness and cracking resistance, the aluminum boride phases were ranked as follows:  $\alpha$ -AlB<sub>12</sub>,  $\gamma$ -AlB<sub>12</sub>, AlC<sub>4</sub>B<sub>24</sub>, Al<sub>3</sub>C<sub>2</sub>B<sub>48</sub>. All of these phases were much harder than  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>. Al<sub>3</sub>C<sub>2</sub>B<sub>48</sub> crystals are just as hard as silicon carbide and nitride crystals, and their cracking resistance is comparable to that of diamond and zirconium dioxide single crystals and exceeds that of cubic boron nitride two-fold. The static compressive strength of these crystals is also comparable with that of several grades of synthetic diamonds. The hardness and cracking resistance of the  $\gamma$ -AlB<sub>12</sub> crystals decreased rapidly as the load on the indentors was increased; this was attributed to changes in the radial cracks. The cracking resistance of the low-temperature Al<sub>3</sub>C<sub>2</sub>B<sub>48</sub> phase was higher when the A-phase predominated; microhardness was not affected by the ratio of A and B phases. References 22: 6 Russian, 16 Western.

13050/12955

CSO: 1842/48

## THE SPECIFIC HEAT CAPACITY OF KIBOR

Kiev SVERKHTVERDYIE MATERIALY in Russian No 6, Nov-Dec 86 (manuscript received 23 Oct 85) pp 22-24

[Article by V. V. Miklushis, T. D. Isitinskaya and A. P. Podoba (Kiev), Superhard Materials Institute, Ukrainian Academy of Sciences]

[Abstract] The specific heat capacity of Kibor (trademark) cubic boron nitride synthesized at the Superhard Materials Institute of the Ukrainian Academy of Sciences was studied. Kibor is stronger, more heat resistant, and has more homogenous monocrystals than other types of cubic boron nitride. Another distinction is the translucence and yellowish-orange shade of its monocrystals. About 288 milligrams of individually selected monocrystals with a grain size of 125/100 were used in the study. The specimen was exceptionally homogenous, and all the crystals appeared identical on the outside. X-ray diffraction analysis indicated that admixtures of hexagonal boron nitride constituted less than 0.5% of the mass. Specific heat capacity was studied on a DSK-111 differential scanning calorimeter made by the French company Setaram [transliteration]. The temperature ranged from 300 to 900 K and was increased by intervals of 5 K. Prior to testing the Kibor, the specific heat capacity of corundum was measured on the DSK-111. The specific heat capacity of the Kibor ranged from 0.158 to 0.404 (Joules/kg·K); this range is consistent with previously obtained data. The Debye temperature values were also consistent with those obtained in previous studies. The specific heat capacity of Kibor as a function of temperature was similar to that for diamond materials, although the Debye temperatures were somewhat lower within the range of temperatures tested. The uniqueness of Kibor's thermodynamic properties was attributed to the different nature and energy of the interatomic bonding of the crystalline structure. References 10: 8 Russian, 2 Western.

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# THE UNIQUE CHARACTERISTICS OF THE STRUCTURE OF COMPOSITE MATERIALS MADE ON A BASE OF SPHALERITE-ANALOGOUS BORON NITRIDE

Kiev SVERKHTVERDYIE MATERIALY in Russian No 6, Nov-Dec 86 (manuscript received 23 Oct 85) pp 24-28

[Article by A. I. Ignatusha, A. V. Lysenko, V. G. Delevi, S. A. Bozhko, A. A. Svirid, Ye. S. Cherepenina, N. G. Bagno, Superhard Materials Institute, Ukrainian Academy of Sciences, Kiev]

[Abstract] BN<sub>sph</sub> powder was sintered onto a substrate made of tungsten-free KKhN15 alloy in a toroidal high-pressure apparatus. Sintering temperatures were 1773 and 2123 K, and pressures ranged from 7.7 to 10.0 HPa. All the studies were done on cross-microsections in the center of the cylindrical specimens. Metallographic studies were done on a Neophot-21 electron microscope. A Camscan was used for scanning electron microscopic studies. X-ray microspectrography was done on a Microscan-5 microprobe. Hardness was measured with a Knoop indenter on a PMT-3 instrument at a load of 9.8 N. The cutting layer of the sintered specimens consisted of comparatively large grains of the BN<sub>sph</sub> powder, a fine-grained mixture of this powder and metal, and individual, acceptably uniformly distributed areas of bright metal phase. Nickel and an alpha-BN phase were found along with the primary beta-BN phase. Some of the individual inclusions of the metallic phase had a chromium concentration of 16% to 18% of the mass. The maximum concentration of nickel-solute chromium was found where the BN<sub>sph</sub> layer conjoined with the substrate; almost no chromium was found in the outer part of the BN<sub>sph</sub> layer. A concentration of 0.1% to 0.5% chromium nitride was also found in the cutting layer. At a constant temperature, increased pressures were associated with a drop in the total nickel and alpha-BN content. The reverse was true when sintering temperature was increased while pressure was held constant. Macro stresses  $(\Delta d/d)_I \cdot 10^{-4}$  ranged from -2.8 to -5.6; micro stresses  $(\Delta d/d)_{II} \cdot 10^{-3}$  from 1.0 to 1.6. The compressive stresses detected in the BN<sub>sph</sub> layer were attributed to the formation of a continuous frame-reinforced structure on a BN<sub>sph</sub> base. The hardness of the cutting layer grew when pressure was increased during sintering. The structure of the material is thermodynamically and mechanically compatible and had the greatest resistance to wear when its compressive stresses are maximal. References 14: 11 Russian, 1 Ukrainian, 2 Western.

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## A DENSE AND STRONG CERAMIC MATERIAL MADE FROM ZIRCONIUM DIOXIDE

Moscow STEKLO I KERAMIKA in Russian No 12, Dec 86, pp 15-16

[Article by Ye. S. Lukin, candidate of the technical sciences, M. G. Sukhikh and V. N. Moiseyenko, engineers, D. I. Mendeleyev, Chemical Technology Institute, Moscow]

[Abstract] Ceramic material made from partially stabilized zirconium dioxide containing 3%  $Y_2O_3$  was studied. The specimens were made by semi-dry pressing of powder with a particle size of 0.5  $\mu m$  and sintering the material at 1200° to 1600°C with a holding period of five hours. X-ray phase analysis showed tetragonal, cubic, and a slight quantity of monoclinic modifications of the zirconium dioxide present in the ceramic. Microscopic analysis showed that the ceramic was made up of densely coalesced round grains. After firing at 1600°C, the specimens had an apparent density of close to 6.0 g/cm<sup>3</sup>, a flexural strength of 600 to 700 MPa, with some specimens as strong as 800 to 850 MPa, and a particle size of less than 1  $\mu m$ . The heat resistance of the ceramic was also studied. References 3: all Western.

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UDC 666.3--183

## INCREASING THE RATE AT WHICH CERAMIC CASTINGS UNDERGO PRELIMINARY HEAT-TREATMENT IN AN ULTRA-HIGH FREQUENCY MAGNETIC FIELD

Moscow STEKLO I KERAMIKA in Russian No 12, Dec 86, pp 18-19

[Article by Ye. N. Prozorov and V. S. Glazachev, candidates of technical sciences, Moscow Chemical Machine Building Institute, Scientific Research and Experimental Institute of Automobile Electrical Equipment and Automobile Instruments (NII avtopribor)]

[Abstract] The ultra-high frequency pulse heating of ceramic castings was studied to determine whether this method could be used to extract the binder from the ceramic body. To improve the dielectric properties of the specimens and to improve their ability to absorb the energy, glycerin in the amount of 2% to 7% of the mass of the dry body was added to the slip. The glycerin had a high imaginary component of the absolute dielectric constant, a boiling point of at least 200°C, and stable physical and chemical properties. Specimens 5 to 20 mm long and 10 to 40 mm in diameter were placed on a fluoroplastic plate in the resonator chamber of an experimental ultra-high frequency generating apparatus. Porous ceramic substrates 5 to 35 mm thick served as the adsorbent. The initial concentration of binder in the specimens ranged from 12.5% to 14%. Two series of experiments were carried out. In the first series of tests, which were done at low temperatures, pulse

length was 60 s, and the pulses were 10 to 120 s apart. These tests showed that up to 10% of the binder was drawn off through the porous substrate in liquid form and, as a result, the viscosity of the system and the strength of the castings increased. In the second series, the castings were held at a temperature of 60°C for 15 to 20 minutes before carrying out the basic binder extraction process. The pulses lasted 30 s and were 4 to 5 minutes apart. With a pulse length of 60 s, most of the binder (residual concentration 3.5%) was drawn out within 3.5 hours. Less stringent heating conditions required more time to extraction the binder. References 4: all Russian.

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UDC 543.42:546.81:666.1

#### THE SPECTROPHOTOMETRIC DETERMINATION OF MICROQUANTITIES OF TIN IN GLASS

Moscow STEKLO I KERAMIKA in Russian No 12, Dec 86, p 23

[Article by V. G. Amelin, P. A. Andreyev, candidates of the chemical sciences, and O. A. Maksimov, engineer, Vladimir Polytechnical Institute]

[Abstract] A general method of spectrophotometrically determining microquantities of tin in silicates was tested and evaluated. Weighed quantities of 0.5 g of crystal and 0.1 g of quartz were placed in a platinum cup, to which was added 1 ml of sulfuric acid, 1 ml of concentrated nitric acid, and 10 ml of hydrofluoric acid, which were evaporated to obtain a heavy concentration of sulfuric acid vapors. The mixture was cooled and transferred to a 100-ml flask. An aliquot portion of the solution was placed in a 25-ml graduated flask, to which was added 2 ml of a 5 M solution of sulfuric acid, 2 ml of 30% hydrogen peroxide, 0.2 ml of a 0.005 M solution of o-nitrophenylfluoron, and 2.5 ml of a 0.01 M solution of OP-10 polyoxyethylated alkylphenol ether or cetylpyridine chloride. The solution was mixed, and after 20 minutes the optical density was measured in a dish. The thickness of the layer was 1 cm, and the maximum luminous absorption was 540 nm relative to the inert solution. Tin content was determined from a graduated graph plotted with data similar to that obtained in this experiment. References 2: both Russian.

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POWDER METALLURGY PLAYS IMPORTANT ROLE IN ECONOMIC GROWTH

Minsk KOMMUNIST BELORUSSII in Russian No 9, Sep 86 pp 53-59

[Article by Professor O. Roman, doctor of the technical sciences and general director of the Belorussian Scientific Production Association for Powder Metallurgy: "Powder Metallurgy: Oriented Towards Faster Growth"]

[Text] The 27th CPSU Congress has defined the nation's highest economic priority in terms of a decisive changeover to the tracks of faster growth for the national economy. Specifically, this means making a dramatic improvement in the engineering of machinery and equipment and emerging at the forefront of scientific and technological progress in possession of the highest level of national productivity in the world.

The scientists, engineers, and workers of our scientific production association have heeded this directive as a blueprint for action. For a number of reasons, powder metallurgy is on the cutting edge of technological progress. In the first place, it has the basic advantage of being a waste-free method of production that utilizes 95 to 98 percent of its materials while having high labor productivity and a high ratio of capital to labor. This new method also saves about two tons of rolled metal for each ton of product. The savings realized from the production of one thousand tons of parts made from powdered metals exceeds two million rubles in many cases. Moreover, 80 machining tools are released for other uses, and fewer workers are needed.

In the second place, powder metallurgical methods make it possible to create materials with specific, pre-set properties that are difficult, if not impossible, to obtain otherwise. Furthermore, parts made from powders are two to three times more functional than similar parts made from common metals and alloys.

Add to this the ongoing efforts to wed powder metallurgical technology with electronics, which, as everyone knows, gave rise to the hallmark of modern industry -- flexibility, i.e., the ability to quickly and easily make the adjustments necessary to make any type of production run, even small ones, and, when possible, using few or no people. All that should be needed are skilled personnel to run systems of machinery that operate with a great degree of reliability at every stage of the industrial process.

All of these characteristics provide justification for putting powder metallurgy in the same category with advanced technologies such as membrane, laser, plasma, electron-beam, and others. Our production association is conducting scientific inquiry in several directions. The first, and perhaps highest, priority, is the formulation of materials. The granulated stock -- metal powder with additives -- must be endowed with a specific shape. This can be done in a number of ways. One way is to use pulse methods, in other words, the energy generated by an explosion to compact and obtain various composite materials. This idea was born as the answer to the low efficiency of conventional compacting due to the irregular distribution of pressures and the impossibility of making large parts. If compacting is done in some type of fluid, even water, the pressure will be evenly distributed. The energy released by the non-destructive detonation of powder charges helps to dramatically increase the productivity of hydrostatic equipment already on line.

Ours was the first association to formulate the phenomenological theory of the shock-wave plastic deformation of porous bodies. In conjunction with the All-Union Scientific-Research Institute of Metallurgical Machinebuilding, we built specialized hydrodynamic machines, each of which saves at least one million rubles annually.

Another area that we consider extremely important and beneficial, in terms of both ideas and their realization, is the formulation of porous materials from metal granules and the use of these materials to make new designs, particularly those that were previously unfeasible. Our metal powder materials work on the earth, in water and air, and in space. In particular, heat pipes, or, as they are sometimes called, superconductors of heat, and all types of filters are being widely used in medicine, biology, and by the chemical industry. They are also used to filter fuel and metallurgical electrolytes, liquid foodstuffs, and industrial run-off. In this regard, it is very important to make porous materials that have pre-determined properties. For example, sintered shapes, as they are called, made from porous materials, were developed at our association and portended a complete turnaround in the whiteware industry. Each of these shapes can function for at least 8,000 cycles and can be recycled afterwards if necessary. These shapes have already gone through approbation at the Dobrush, Minsk, Tashkent, and Taymazin whiteware plants.

Another area that we consider to be one of the most important has to do with formulating friction materials that can function under conditions other products cannot endure. Here is an example: the use of a disk with linings made of M-106 material in the brakes of graders has reduced their braking distance 2.5-fold and has increased brake life 10-fold. The association has also formulated friction materials on an iron base. They are stronger, heat resistant up to temperatures of 800 degrees at the friction surface, and contain minimal quantities of scarce and costly materials.

More needs to be said about one of the newest and, perhaps, most promising areas of research at our production association -- the formulation of protective gas-heated coatings. A layer of metal powder restores the original dimensions of the worn part, thereby making it functional again, and this is

a critical problem for any enterprise or business. The benefits of this method consists in that it affords the opportunity to build facilities for applying protective coatings directly on the premises of the enterprise. Already, there are more than 25 of this type of facility within the republic, and the 12th Five-Year Plan intends to double that number. This new method is highly thought of at the Ministry of Light Industry, which has adopted a special long-term program to introduce protective coatings. Similar joint programs with the production association are being prepared by the Ministry of Automotive Transport and the Ministry of Construction Materials in Belorussia. It would be desirable if the new technology also came into the hands of all the numerous members of the army of agricultural mechanizers.

All of the foregoing explains why the party and economic organs of the republic are according so much attention to the development of powder metallurgy, which can solve problems of great significance for the economy.

At one time, there was a dilemma: whether to inject new technologies into industry or create a specialized branch of industry that would supply industrial enterprises with new products regardless of their administrative affiliation. The first alternative had already been tried: whoever needed advanced technology adopted it.

However, the second alternative appeared more efficient. Local conditions played an important role in the decision. By this time, Belorussia boasted a solid store of scientific knowledge in the area of "powders". Large machine-building plants -- tractor, automotive, bearing, and others -- immediately turned to us for help in creating their own facilities, many of which are now operating successfully. But the question remained open: How to proceed with the other, smaller enterprises?

This question was thoroughly discussed by the Central Committee of the Belorussian Communist Party and by the Belorussian Council of Ministers. The conclusion was unanimous -- it was time to build interbranch production facilities that could meet the demands of the region for powder metallurgical products. The new scientific production association comprised our institute as the head organization, the Special Technology Design Bureau together with its experimental production plant, and the powder metallurgy plant in Molodechno, which can produce 10,000 tons of output annually.

The first partner with which we established business relations was the Minsk Bearings Plant. The benefits of this relationship were mutual, and not only because our association is keenly interested in seeing its developments put to use, but also because the plant itself, which has workshops crammed with machine tools and automated lines, is acutely in need of technical support from the association. Our collaboration will continue to grow. For example, this year we will be doing testing and analysis for the purpose of refining the technology for manufacturing bushings and rings. In addition, a combined effort will be made to build up the output of standard bearing races that are already in production.

A new technology for making starter commutators for internal combustion engines was developed for and adopted by the Borisov electrical automotive equipment plant. The enterprise now saves 700 tons of copper commutator shapes.

Here is another example. Thermal power plants have atomizers in the fuel-oil injector nozzles of their generators. Our scientists proposed making this part out of powder composites. The innovation surpassed all expectations, and now the atomizer functions not for 500 to 800 hours, but for 4,500 to 5,000 hours.

Today, one can already talk about some of the results of integrating science and production. Foremost among these is that the sophisticated designs of the production association have been adopted by scores of enterprise customers, who saved more than 67 million dollars over the course of the 11th Five-Year Plan. They also saved 3,500 tons of metal, 72 million kilowatt-hours of electricity, and 250 thousand tons of standard fuel units. Our customers released 540 people who are now available for work elsewhere.

One should consider that the association is really just now beginning to gather momentum. The Molodechno plant has not yet reached a third of its rated capacity, and the demand for powder metallurgical products for now greatly exceeds the supply. This circumstance must be taken into account when taking orders. Preference is given to those enterprises that are less well endowed from a technical standpoint, as well as to collectives that are turning to us with requests for products that can only be made with metal powders, or for parts with complex geometrical shapes.

I think that I am not making a mistake when I say that our association earned its reputation as a business-like, reliable partner precisely because of the great sophistication of its engineering and design work. We have put together a capable, qualified staff of scientists that includes three doctors of science and 67 candidates. The structure of the production association and the reliable base of technological engineering that it has at its disposal cuts the time from conceptualization to adoption in half when compared against the usual standard.

Each year, powder metallurgy is the object of intensive development efforts in many countries. For now, it is somewhat difficult to compare the results of technological progress at home with those of foreign nations because of the lack of, as they say in these situations, a common unit of measurement. But one thing is clear: it is much more difficult for the West to achieve the same degree of cooperation and common effort among organizations, and, at times, quite impossible. For example, such world-famous American companies as General Motors, General Electric, and others, which are doing their own research on powder metallurgy, are doing everything possible to keep it a secret, thereby guarding against potential rivals. The proof of this is the industrial espionage that literally traumatizes western firms, and the countermeasures that they take to protect themselves against it.

In our country, the USSR State Committee on Science and Technology coordinates and implements scientific developments and a concrete program for developing the powder metallurgical industry. Our association, for example, participates in the work of the Interbranch Scientific and Technical Complex (MNTK), which exists to implement five union and four republic comprehensive programs. Our production association serves as an executive organization for the republic program "Powder Metallurgy" and for the USSR Ministry of Higher Education's program of the same name.

In its Political Report to the 27th Party Congress, the Central Committee emphasized the necessity of greater efficiency on the part of scientific research institutions and new forms of integrating science and production. For this reason, special attention is being given to assembling interbranch scientific and technical complexes that exist to accelerate the development of the basic directions of priority and to coordinate all the work done in these areas. We maintain close ties with industrial enterprises, scientific institutions, educational institutes, and, above all, the Belorussian Polytechnical Institute, where our efforts were instrumental in the establishment of a powder metallurgy department. On the premises of the production association, undergraduate students do laboratory research and prepare their coursework and graduation projects, and graduate students work on their dissertations. Every year, more than 50 of the institute's graduates come to work at our association. This practice makes it possible to staff a powder metallurgy research center with qualified specialists and to greatly reduce the time it takes for young engineers to learn the ropes. In this manner, the Belorussian Polytechnical Institute prepares its students to join the association's staff, and the association, in return, "exports" its specialists to industrial enterprises, where "powder" divisions are set up.

In addition, the production association participates in the interbranch scientific and technical complex "Powder Metallurgy" with the executive organization -- the Institute of Metallurgical Problems of the UkSSR Academy of Sciences. This means that the structural and organizational problems are resolved in principle at the national level.

This is yet another reason why the barriers that at times stand in the way of progress and the faster adoption of scientific developments are all the more disturbing. Here is an actual and, unfortunately, unpleasant example. Plans for the future development of the Molodechno plant include a new type of compacting and sintering equipment, the manufacture of which was planned for by the Ministry of the Machine Tool Industry and the Ministry of Light Industrial Industry as early as in the 11th Five-Year Plan. However, the timetables for starting up the production of the new types of presses and furnaces are in many ways incompatible with the plant's depreciation schedules for its capital equipment, and this places the timely augmentation of its productive capacity at risk.

Moreover, the automated presses currently being produced for the powder metallurgy industry are of poor quality. Neither the prototypes nor the series-produced presses are equipped with mechanisms for storing the compacts or with

special devices for inventory control or for hooking up with automated control systems. The results of such an approach are not reassuring. At the Molodechno plant, 30 presses manufactured at the Pinsk forging and pressing equipment plant of the Ministry of the Machine Tool Industry are currently down. The marriage between our plant and the manufacturer is costing us dearly: the production of complex precision parts -- precisely those that users need so badly -- is impeded.

Another problem is causing us anxiety. Soviet industry is still not producing highly efficient furnaces, which to a great degree is holding back the growth rate for the production of powder metallurgical products. The large, specialized producers of sintered products under the aegis of the Ministries of Ferrous Metallurgy, the Automotive Industry, and the Tractor and Agricultural Machine-Building Industry are dealing with the problem in one of two ways: by importing the necessary equipment or by organizing its manufacture at ministry enterprises. In order to do away with this complication, the Ministry of the Electrical Equipment Industry manufactured experimental prototypes of highly productive furnaces and sent them over to our association for industrial "hot tests". However, the prototypes were delivered without the necessary auxiliary components and refractory materials and were made with several serious defects, all of which led to disruption of the test schedules and delays in getting the equipment on line.

Now, about the powders themselves. The Molodechno plant plans to use atomized iron powder as a raw material. The powder is produced at the metallurgical plant in the Krasnyy Sulin, but production is lagging behind schedule.

PZh-4 (M2-M3) iron powder, which is now being mass-produced by the Ministry of Ferrous Metallurgy, is expensive. A two to 2.5-fold increase in powder prices (whereas at the same time the price for rolled metal went up by only 30%) led to a sharp drop in the cost savings realized from the use of powder metallurgical methods. The profitability of these methods hinges on significant reductions in the labor intensiveness and on higher labor productivity. We plan to release 12 to 15 percent of the production force, improve working conditions and standards of production, and mechanize 96 to 98 percent of production.

A little bit about adopting new technology. As a result of efforts by the Ye. O. Paton Institute, engineering centers are being established, the main goal of which is to bring scientific developments up to the level of industrial technology. From our earliest days, we set such a goal for ourselves even at the level of the laboratory. However, it goes without saying that two partners are required to solve a problem: the scientific institute and the enterprise, and the latter partner must have a genuine interest in the problem. There are positive examples of such cooperation, such as our development of efficient bimetals at the request of the Ministry of Non-Ferrous Metallurgy. At the same time, all of our attempts to find practical applications for bimetals are yet to be successful.

The system for supplying materials and equipment to scientific institutions also needs improvement. For example, the practice of booking orders a year in

is not practical for us, especially now that the results of scientific research must be implemented with much greater dispatch.

The way out of this situation seems to lie in giving scientific institutions the right to send in orders for day-to-day operations to supply organizations on a quarterly basis, or to allow them to contract directly with the enterprises that manufacture the needed equipment and instruments. Some basic materials can be obtained from other enterprises, organizations, and scientific research institutes. However, this practice is for the mean time categorically forbidden.

It has also become necessary to solve certain organizational problems. The scientific production association has for several years been the de facto interbranch scientific and technical complex for the republic. Its departments fill the role of engineering centers. It is here that we run head-on into the poorly developed mechanism for planning the association's scientific developments. At the present time, there are three financing systems: "Nauka [Science]", "Nauchnoe obsluzhivaniye [Scientific Support Services]", and "Proizvodstvo [Production]". This year, we amalgamated the scientific-research institute and the Special Technology Design Bureau into a single research and engineering institute, thereby organizationally eliminating the break in the research and development chain. Nevertheless, the employees in the different subdivisions of the institute are on different pay scales.

The association is still provided with plan indicators broken down into the "Science", "Scientific Support Services", and "Production" categories. As it turns out, many colleagues are compelled to work on one and the same problem -- that of making scientific developments and ideas suitable for adoption by industry. However, some of the work is planned under the heading "Science", some under "Scientific Support Services", and some under "Production". From this comes different planning systems, different accounting systems, and different pay scales determined not according to the nature and importance of the work, but according to a table of job titles.

For all practical purposes, we cannot, in the course of a calendar year, take on a new work order, even if it is very interesting. It is not written into our plans, which means that all the income generated by solving this problem goes into a budget -- we do not see a kopek of it. The mechanism for providing scientists with a monetary incentive for their work is, as it was before, not functional.

The problems, as can be seen, are many. However, all of them, in our opinion, share one common feature -- they lie in the sphere of business relations between partners who are interested parties -- science and production -- and a fundamental restructuring of our, as we shall put it, scientific production thought processes is not required to solve these problems.

Some people are of the following opinion: "Let's replace conventional parts with parts made from powders in some piece of engineering -- that will save us some money." But in which piece of engineering? In the one that was never, from the time it was born, designed to have powdered metal parts? This kind

of approach to the problem is fallacious to the core. Powdered metal parts are unusually diverse, "flexible" in their applications, and they need to be incorporated into designs immediately. The use of plastics is a good example of this. The same thing must happen with "powders". The primary responsibility for this is borne by our association, which, up to now, has not provided complete reference materials on the properties of our products and the technologies for using them.

Our production association's field of activities is constantly expanding. Recently, members of the Brest oblast committee of the Belorussian Communist Party came to us with a proposal for expanding the use of powder metallurgical methods in the region's enterprises. Our staff members have been at many Brest enterprises, have studied currently operating industrial processes, and have drawn up a plan for introducing products made from powders. At the same time, our scientists and specialists have started giving special courses to designers and industrial engineers on the advantages of using our methods. Already, positive results of this work are being seen in the Brest region.

During the last five-year plan, the scientific-production association presided over the introduction of 137 completed projects, which have received permanent registration at more than 100 of the country's enterprises. On the basis of the results of the 1985 All-Union Socialist Competition, the association was awarded the Perpetual Order of the Red Banner of the CPSU Central Committee, the USSR Council of Ministers, The All-Union Central Soviet of Trade Unions, and the Central Committee of the All-Union Leninist Communist Youth League.

This triumph in labor was the result of goal-oriented work by the association's party organization, which mobilized the employees to solve specific national economic problems, and which puts its efforts towards the creation of an atmosphere of creative inquiry in all the subdivisions of the scientific production association. This greatly facilitates a sober attitude towards criticism and a strict regard for critiques and suggestions and for the system of controlling the decisions that are made accordingly.

The main goal of our staff and employees for the current five-year plan is to make the basic and enquiring nature of research and development more profound, and to develop fundamentally new industrial processes and equipment. During the 12th Five-Year Plan, these processes will not only be developed, but will also find industrial application.

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## STRAIN-HARDENING OF POWDER COMPACTS

Minsk NARODNOYE KHOZYAYSTVO BELORUSSII in Russian Nov 86, p 32

[Article by Candidate of Technical Sciences V. Fedorov: "Strain Strengthens"]

[Text] The existing iron-based powder compacts frequently do not satisfy the requirements for surface hardness, wear resistance, and other service properties placed on them. Chemical-heat methods are not very effective because they frequently lead to corrosion cracking of surface layers of sintered compacts. Also, this method of treatment is fairly labor-intensive.

It is of practical interest to use methods of plastic surface strain in order to harden such parts. For this purpose, one uses multiroller rolling equipment that impart a surface roughness of 0.3-0.63 microns and a waviness of 1.3-1.6 microns with the use of forces between 2500 and 5000 Newtons.

The effectiveness of the method is confirmed by the results of a study of their wear resistance compared to that obtained by turning and grinding. The powder compact specimens hardened by plastic straining of the surface showed 1.3 times less wear than ground specimens and almost 1.5 times less wear than those hardened by finishing on a lathe. Furthermore, the rubbing surfaces of such compacts show almost no seizing compared to compacts hardened by grinding.

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## ALLOY PRODUCTION BY HIGH-TEMPERATURE SELF-PROPAGATING SYNTHESIS

Tblisi MOLODEZH GRUZII in Russian 13 Nov 86, p 2

[GRUZINFORM Article: "Unusual Alloys"]

[Text] A new tool material developed at the Metallurgy Institute of the Georgian SSR Academy of Sciences fully replaces expensive steels used in the production of cutting tools. Unlike the existing standard grades, the alloys of the Georgian scientists do not contain scarce tungsten or nickel. But their service properties exceed considerably those of the existing materials. They are much cheaper, several times lighter, and offer several times longer service life and a higher wear resistance.

The new materials were obtained by an unusual method. The scientists used an advanced technology recently discovered by Soviet scientists: self-propagating high-temperature synthesis (SHS).

"This fundamentally new method of production of substances and materials is based on the chemical reaction of combustion," said the head of the SHS laboratory G. Tavadze to the GRUZINFORM correspondent. "Its appearance is impressive--a running, brightly luminous fire wave leaving behind a tail of slowly cooling alloy. Neither furnace nor other heat sources are needed to heat the powder mixture to high temperatures. It is sufficient to heat only a small area of the mixture surface in order to start the reaction. Unlike in the production of alloys in furnaces, the chemical reactions here do not take place in the entire volume of the mixture but spread over the material spontaneously, layer by layer. This process does not require complicated and cumbersome equipment and can be employed by any machine-building shop or plant, ensuring a high productivity. The new technology makes it possible to obtain the most valuable materials for use, for example, under extreme conditions such as high and low temperatures, extremely high pressures and vacuum, high speed cutting of metals, and abrasive wear. Hard alloys made by these methods can also be used as strong coatings on metal parts such as press dies and plow parts, and centrifuging produces strong laminated tubes, reliable tools for drilling equipment, etc. High-temperature synthesis is capable of welding even normally nonweldable material pairs such as graphite to graphite and molybdenum to tungsten. This produces a monolithic, dense seam that strongly bonds the specimens.

The use of the new method makes it possible to free working spaces and equipment, increase production beyond the existing possibilities of plants or shops, lower the unit cost of the parts, improve the working conditions, and, importantly, ensure clean environment.

Georgian scientists have made important achievements in a new approach in metallurgy--high-temperature synthesis of high-melting compounds. Specifically, they developed a process for the production of pure boron and superconducting alloys. Exploratory studies are being conducted at the institute with the aim of developing highly effective processes for the production of metals. These studies are of great theoretical and practical significance.

The technologies and materials developed by Georgian scientists are already being introduced at a number of large industrial enterprises of our country. For example, the Izhstal Production Association has achieved savings of 100,000 rubles a year as a result of the introduction of new tungsten-free tool materials. Work has been started to implement the new method also in our republic. At the Tbilisi Electric Locomotive Plant, the Kutaisi Automobile Plant, and the Zestafoni Cable Plant, production areas have been set aside which, when they are started up, will fully satisfy the need of these plants for cheap tool materials made of synthesized alloys. Their use saves a plant 15,000 rubles per ton of tools produced.

"The results of our studies," says associate manager of the project G. Oniashvili, "are the foundations of further technical progress up to the beginning of the 21-st century." The studies and the development of new technologies provide a base for the development of new materials with special properties that satisfy the needs of the continually growing economy of our country and of special areas of technology. The importance of the fundamentally new technology--of the theory and practice of production of economical materials having a broad range of properties--has prompted the establishment of an all-union scientific and technical complex Termosintez. A science and technology center, which is a part of this complex, has been formed at the Metallurgy Institute of the Georgian SSR Academy of Sciences, and an interindustry science and technology council on the high-temperature synthesis of materials has been organized as an adjunct to the State Committee for Science and Technology of the Georgian SSR.

12973/12955  
CSO: 1842/63

## RELATIONSHIP OF CERTAIN CHARACTERISTICS OF GRANULATED WURTZITE BORON NITRIDE POWDERS WITH THEIR MANUFACTURING CONDITIONS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 20 Jan 86) pp 14-17

[Article by V. M. Volkogon, Institute of Materials Science Problems, Ukrainian Academy of Sciences]

[Abstract] A study is made of the specifics of compacting of  $BN_w$  powders by various methods as well as of the influence of the method of preliminary compacting on the specific surface, fluidity and bulk density of the granulated powders. Compacting methods included: hard-alloy press mold with lubricated walls; press mold with plasticizing additive; under high static and dynamic pressure. The density of pressings was determined by hydrostatic weighing or mercury porometry. The pressings were then ground in a porcelain mortar or by rubbing through a 1 mm wire screen and classified. The best properties were those of powders produced by initial compacting under high static and dynamic pressure. Granulation of preliminarily compacted  $BN_w$  powders allows mechanization of the preparatory operations involved in the production of compact products and abrasive grains. References 11: 10 Russian, 1 Western.

6508/12955

CSO: 1842/54

## FORMATION OF SPRAYED HIGH-SPEED STEEL POWDERS WITH SHEAR DEFORMATION

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 24 Feb 86) pp 18-22

[Article by G. Ye. Mazharova, G. A. Vaglyuk, A. I. Bykov and L. A. Poznyak, Materials Science Problems Institute, Ukrainian Academy of Sciences]

[Abstract] A study is made of the possibility of producing blanks of atomized high-speed steel powders by pressing with controlled flow of the compacting material in the direction perpendicular to the application of the deforming stress. By pouring the powder into a ring of copper or steel on a press bed, then pressing the powder in the 6300 kN press, a pressing force system was achieved with significant initial shear deformation followed by high hydrostatic stress. The powder used was nitrogen-sprayed type R6M5K5 high-speed steel. All specimens were found to have high strength after pressing. Addition of a central rod of the same material as the outer ring was found to increase the density of the pressed specimen slightly while decreasing transverse deformation of the ring. Porosity after pressing and subsequent sintering was not over 2.5%. References 10: all Russian.

6508/12955

CSO: 1842/54

## FUSION ON CONTACTING SURFACES DURING HOT PRESSURE WORKING OF POWDER MATERIALS BY VARIOUS METHODS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 12 Oct 84) pp 31-34

[Article by Yu. G. Dorofeyev, V. Yu. Dorofeyev, S. N. Yegorov and S. A. Gorshkov, Novochoerkassk Polytechnical Institute]

[Abstract] A study is made of the specifics of fusion during extrusion or fusion in a vacuum for various types of initial powders. The intergrain fusion surface was studied by electron microscopy of replicas. The electron microscope examination of specimens produced by hot pressure working, with all stages performed under a vacuum, showed that in the 800-1100°C hot recompaction temperature interval, regardless of residual porosity, an intergrain fusion surface without submicropores is formed and there is no gas counterpressure in the process of formation of closed pores. Hot extrusion can be compared to vacuum pressing in its effect on the nature of the fusion zone structure, in that there are also no zones with submicropores. Optimal results are achieved by the use of atomized powder with shear deformations and vacuum. References 7: all Russian.

6508/12955

CSO: 1842/54

## STRUCTURAL SPECIFICS OF COPPER-NIOBIUM POWDER COMPOSITES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 6 Dec 85) pp 66-71

[Article by I. A. Kiyanskiy, Yu. A. Perlovich, T. D. Aksenova, A. A. Rusakov, A. V. Artamoshin and I. S. Dukhovny, Moscow Engineering Physics Institute Gorizont Special Design Bureau]

[Abstract] An x-ray diffractometric study is presented of the structure of microcomposites of the copper-niobium system in various stages of pressure working. Materials were obtained by pressing mixtures of copper and niobium powder, sintering of the blanks and subsequent pressure working by hydroextrusion and cold drawing. Specimens contained 15-40 mass percent niobium. It was found that the half width of the niobium x-ray line decreased with increasing degree of deformation in the specimens, while the angular position of the diffraction maxima shifted in the direction of greater angles, indicating a reduction in distance between planes. Hydroextrusion at 400°C was thus found to decrease the defect content of the crystalline lattice of the niobium fibers. The niobium particles were strip shaped, resulting from the system of slipping activated in the particles during plastic deformation of the composite. With cold drawing at lower temperature, these structural specifics characteristic of hydroextruded materials are less clearly expressed. Decreasing the niobium content increases the effects characteristic of the hydroextrusion process. References 6: 4 Russian, 2 Western.

6508/12955  
CSO: 1842/54

UDC 669.27

## PRODUCTION OF COARSE-GRAIN TUNGSTEN POWDER BY ELECTROLYTIC METHOD

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 16 Jul 85) pp 1-3

[Article by V. A. Pavlovskiy and V. A. Reznichenko, Metallurgy Institute USSR Academy of Sciences]

[Abstract] Laboratory experiments tests were performed in the development of a technology for production of coarse-grain tungsten powder by electrolytic refining in a chloride-fluoride melt. A multicathode electrolyzer was used to facilitate sequential treatment with, and sampling of, the electrolyte without interruption of the process and unsealing the apparatus, a melt of 60% NaCl + 15% NaF + 25% WO<sub>3</sub> having been selected as the electrolyte material. The cathodic current density, a critical parameter determining the structural characteristics of the cathodic deposit,

was varied over the 0.4-1.0 A/cm<sup>2</sup> range and the anodic current density did not exceed 0.1 A/cm<sup>2</sup>. The process temperature was varied over the 830-930°C range. Large needle crystals, 60-70% of them in the -1+0.4 mm size fraction, were produced at 870°C with a cathodic current density not higher than 0.8 A/cm<sup>2</sup>. A semi-industrial apparatus has been built on this basis for refining tungsten tailings at the Uzbek Refractory and Heat-Resistant Metals Combine. It includes an electrolyzer with 400 A capacity in the form of retort made of stainless steel, containing two beakers, 250 mm in diameter, made of nickel and graphite respectively. The electrolyzer is filled with nitrogen to provide a sufficiently inert atmosphere. The cathodic current density is cyclically varied over the 0.5-2.0 A/cm<sup>2</sup>, a total of up to 1000 A·h per production cycle being delivered in the process. The powder thus produced is almost free of metallic impurities, except for 0.08-0.3% Mo, and annealing in a tubular high-temperature furnace at 1200°C under a vacuum of 0.133 Pa reduces the carbon content to below 4·10<sup>-3</sup>%.  
References 2: both Russian.

2415/12955  
CSO: 1842/55

UDC 621.762

#### EFFECT OF ADDING In<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, WO<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub> OXIDES ON PROPERTIES OF Ag-CdO COMPOSITE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 11 Aug 84) pp 20-26

[Article by N. L. Pravoverov, M. P. Afonin, L. V. Vyatkin, N. M. Mashkov and I. A. Tribunskaya, All-Union Electromechanics Scientific Research Institute]

[Abstract] An experimental study of the 85% Ag - 15% CdO cermet and its four modifications for electrical contactors was made, the purpose being to determine the effect of replacing 5% CdO with In<sub>2</sub>O<sub>3</sub>, SnO<sub>2</sub>, WO<sub>3</sub>, Bi<sub>2</sub>O<sub>3</sub> respectively on the erosion resistance and the welding resistance. Specimens of the four ternary composites 85 Ag - 10 CdO - 5 m.o. (m.o. - metal oxide), disk contactors 2.2 mm thick and 8 mm in diameter, were produced by the same technology from Ag powder and respective oxide powders. Their microstructure was examined metallographically and by x-ray diffraction. Erosion tests were performed on contact pairs in a MAK V machine for determining the loss of mass in a given number of "make-break" cycles and in an EM 150 machine, in the latter for determining the loss of mass due to electric discharge after "break" under a current of 100 A and due to mechanical impact during "make", both machines having been adjusted to allow only one bounce after an impact. The tests were performed with alternating current from a 220 V - 50 Hz source, with polarity reversal after every "make-break" cycle, with a "make" velocity of 0.20±0.01 m/s, and with a "make" pressure force increasing from initial 14.7±0.5 N to final 17.7±2 N. Welding resistance was measured in terms of the force necessary to

separate contactors passing a 50 Hz current of 500-3500 A amplitude during one half-period after they had pressed together with a force of 5 N. An evaluation of the results, including a statistical analysis of the test data and taking into account the thermophysical properties (melting and boiling points) of all five oxides as well as their grain size fractions based on microstructural examination, indicates the effect of partial replacement of CdO. Replacement with  $\text{Bi}_2\text{O}_3$  increases the erosion resistance most and also increases the welding resistance. Replacement with  $\text{In}_2\text{O}_3$  increases the welding resistance most but decreases the erosion resistance. Replacement with  $\text{WO}_3$  decreases the erosion resistance without significant change in the welding resistance. Replacement with  $\text{SnO}_2$  does not significantly change the erosion resistance and the welding resistance. Phase analysis has revealed a buildup of compound oxide  $\text{CdIn}_2\text{O}_4$  on the contact surface, which not only does not form a protective layer but actually stimulates erosion, and formation of  $\text{CdWO}_4$ , not on the contact surface but together with  $\text{Ag}_2\text{WO}_4$  underneath so that it also builds up a protective layer. Therefore, 85 Ag - 10 CdO - 5  $\text{In}_2\text{O}_3$  and 85 Ag - 10 CdO - 5  $\text{WO}_3$  are unsuitable for this application. References 13: 7 Russian, 6 Western (all in Russian translation).

2415/12955  
CSO: 1842/55

UDC 669.187.522

#### ELECTROCHEMICAL DEOXIDATION OF METAL WITH USE OF MgO CERAMICS

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 13 Mar 86) pp 151-152

[Article by A. Yu. Gashimov, R. G. Kayumov and B. V. Linchevskiy, Moscow Evening Metallurgical Institute]

[Abstract] Electrochemical deoxidation as an effective method of refining a metal without forming nonmetallic inclusions is considered, such a treatment being usually applied under vacuum in an induction furnace with a lining made of almost pure fused MgO (mannesite). An experimental study was made with use of MgO as solid electrolyte for refining 008FeRef iron ( $\leq 0.008\%$  C, 0.03% Si, 0.01% Ni, 0.025% N<sub>2</sub>, 0.0164% O<sub>2</sub>). Crucibles made of pure MgO, of MgO with  $\text{TiO}_2$  or  $\text{ZrO}_2$  added, and of  $\text{ZrO}_2$  stabilized with 8%  $\text{Y}_2\text{O}_3$  were used as electrolyte, the anode being made of Mo +  $\text{MoO}_2$  and the liquid metal serving as the cathode. Electrolysis was performed with a VSA-5K constant-current source. The results indicate that pure MgO lowers the oxygen activity from 0.045 to 0.005, while addition of  $\text{TiO}_2$  or  $\text{ZrO}_2$  further increases the efficiency of the process. The optimum electrolyte composition was found to be 90% MgO + 10%  $\text{ZrO}_2$ . References 1: Russian.

2415/12955  
CSO: 1842/46

UDC 621.365:621.785.6-982

## VACUUM HARDENING OF SINTERED STEEL GEARS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 10, Oct 86 (manuscript received 4 Dec 84) pp 89-93

[Article by E. N. Marmer, V. I. Vislobokov and A. G. Bolshov, All-Union Electrothermal Equipment Scientific Research Institute; Altay Aggregates Plant]

[Abstract] A study is made of the hardening of sintered parts in oil after heating in a vacuum. The work is performed on oil pump gears manufactured from type PZh2M3 powder at 0.6 GPa. Sintering was performed at 1150°C in dissociated ammonia, 100-120 minutes holding time, with zinc stearate plasticizer which was removed at 650°C. After sintering the parts were calibrated, decreasing surface layer porosity by 3-4%. Hardening was performed in a commercial vacuum furnace at 810, 860 and 900°C, 30 minutes holding time, with quenching in type V3-1 oil. It was found that hardness could be increased by a factor of 1.7-2 by this method. Vacuum hardening preserves the initial surface quality and color of the products.

References 5: all Russian.

6508/12955

CSO: 1842/54

UDC 539.374:539.214:621.771

## CHARACTERISTICS OF STRIP ROLLING WITH NONUNIFORM TRANSVERSE REDUCTION

Moscow IZVESTIYA VYSSHIKH UCHEBNIKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 17 Feb 86) pp 57-60

[Article by V. K. Vorontsov and S. L. Klyuchko, Moscow Steel and Alloys Institute]

[Abstract] Hot rolling of low-carbon steel strip is analyzed on the basis of laboratory measurements by the method of moire fringes made on eight model specimens of lead (Wood's metal) in a 5-factorial 2-level experiment.

An evaluation of the results reveals the effect of nonuniform transverse reduction with burring in horizontal rollers and indicate the need to decrease the size of burrs so as to avoid buildup of dangerous tensile stresses, which can be achieved by minimizing the precompression in vertical rollers. References 4: all Russian.

2415/12955  
CSO: 1842/46

UDC 621.785:535.211:669.15-194:669.017

#### EFFECT OF OXIDE INCLUSIONS ON HARDENING OF STEEL BY LASER TREATMENT

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 29 Jul 83) pp 110-114

[Article by S. I. Gubenko, O. A. Demidova and V. N. Varavka, Dnepropetrovsk Metallurgical Institute]

[Abstract] Hardening of six steels (08 rimmed, 08Al, 08Ti, 08Cr, Cr15 ball bearing, 08Cr18Ni10Ti stainless) by laser treatment was studied for the purpose of determining the effect of oxide inclusions (TiO, TiO<sub>2</sub>, FeO-TiO<sub>2</sub>, Cr<sub>2</sub>O<sub>3</sub>, MnO.Cr<sub>2</sub>O<sub>3</sub>, FeO.Cr<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, Mn. Al<sub>2</sub>O<sub>3</sub>, MgO.Al<sub>2</sub>O<sub>3</sub>, FeO.Al<sub>2</sub>O<sub>3</sub>, Fe-MnO, FeO, FeO.Fe<sub>2</sub>O<sub>3</sub>). During laser action the refractory oxides remained all solid or sweated at the edges and the other oxides became liquid in an either solid or liquid steel matrix. The effect of oxides was found to be impurification of the steel matrix and a resulting more nonhomogeneous structure of the case. References 3: all Russian.

2415/12955  
CSO: 1842/46

UDC 669.15'26'24'-194:621.789:620.17

#### WEAR RESISTANCE OF 40CrNi STEEL AFTER LASER TREATMENT

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: CHERNAYA METALLURGIYA in Russian No 11, Nov 86 (manuscript received 6 Feb 86) p 158

[Article by N. M. Mikhin, V. S. Prosolov and N. F. Korzhik, Moscow Petrochemical and Gas Industry Institute]

[Abstract] Hollow cylindrical rollers made of 40CrNi steel pretreated to 300 Brinell hardness, 50 mm in diameter with 10 mm wall thickness, were case hardened by treatment with a continuous-wave CO<sub>2</sub>-laser. Some rollers had been covered with a coating of radiation absorber and others with a lubricant containing boron. Subsequent microhardness measurement with a PMT-3 tester under 1 0.981 N load yielded 9000-9400 MPa for the coated rollers, some 11,200-11,900 MPa for the lubricated rollers and only 3400-3800 MPa

for rollers not hardened. Wear tests were performed in sliding friction against a block made of grade-D pipe steel, at a rubbing velocity of 0.785 m/s under pressures up to 7 MPa, using an SMTs-2M machine with a water + 30% clay bath. The results indicate that laser treatment of this steel appreciably lowers the wear rate and the friction coefficient in an abrasive medium, the wear rate as much as down to 7-10% with the statistical variance almost independent of the friction path.

2415/12955

CSO: 1842/46

UDC 621.778.1.06:669.28

# THE EFFECT OF DIFFERENT VIBRATION-DRAWING PROCESSES ON THE MECHANICAL PROPERTIES OF TUNGSTEN WIRE

Moscow TSVETNYYE MATERIALY in Russian No 11, Nov 86, pp 74-75

[Article by A. N. Shapoval, V. M. Izotov and V. D. Mozolev]

[Abstract] The effect of different vibration-drawing processes on the tensile strength of tungsten wire was studied. The wire used in the study was VA tungsten wire made on a vibration drawing bench equipped with a vibrating drawplate assembly. The initial diameter of the wire rod was 1.45 mm. Before drawing, the wire was heated to a temperature of  $950 \pm 20^\circ\text{C}$ . V-1 Aquadag served as the lubricant. Three variations on the drawing process were used: vibrationless drawing through one draw plate (average logarithmic reduction per passage - 0.25); vibration drawing through one draw plate (reduction per passage - 0.25); vibration drawing through two plates vibrating in opposing phases (average reduction per passage - 0.5). The plates vibrated with a frequency of 47.5 Hz and an amplitude of 1 mm. Drawing speed was 10 meters per minute. Tensile strength was tested on specimens taken from the wire after each passage. The tests were performed on an RMU-0.5 tensile testing machine at a temperature of  $400 \pm 5^\circ\text{C}$ . Wire drawn using the first two variations had roughly the same strength characteristics, although the second variation yielded wire with somewhat greater ductility. Wire drawn using the third variation had a tensile strength that was an average of 9% lower and a ductility characteristic 10% higher than wire produced by the first two variations. The difference in mechanical properties was attributed to the weakening of the wire due to the effects of cyclical stress occasioned by the angular components of the draw plate vibrations. References 5: all Russian.

13050/12955

CSO: 1842/52

UDC 621.791.75:537.525.001.24

ELECTRON EMISSION UPON EVAPORATION OF EASILY IONIZED ADDITIVES IN CATHODE MATERIAL

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 12 Mar 86) pp 1-3

[Article by Academician B. Ye. Paton, V. S. Gvozdetskiy, doctor of technical sciences and Yu. L. Vasenin, engineer, Electric Welding Institute, imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A physical model is suggested for the emission of electrons due to the evaporation of atoms of cathode material additives in the electric field of the cathode potential drop of a welding arc. Results are presented from calculation of the number of emitted electrons per evaporating atom with a potential drop of not over  $1.7 \cdot 10^7$  V/cm and cathode temperature not over 2500K. The possibility is demonstrated of using the suggested mechanism of emission to explain the current transfer on a cold arc discharge cathode when both autoelectron emission and thermoelectron emission, considering the Shottky effect, are slight. The suggested mechanism, interaction of the evaporating atomic core with the cathode metal, leads to capture by an atom of an electron at an energy near the Fermi level. The external electric field supports emission of the electron in the direction of the arc. This mechanism can support emission of up to 100 electrons per evaporating atom. The high effectiveness of this electron emission mechanism, combined with I-F-T emission, can explain current transfer to the cold cathode of the discharge arc. References 9: 8 Russian, 1 Western (in Russian).

6508/12955  
CSO: 1842/59

## INFLUENCE OF NEGATIVE IONS ON VOLTAGE DROP NEAR ELECTRODE IN AN ARC DISCHARGE

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 2 Apr 85; in final form 22 Apr 86) pp 4-9

[Article by Academician, Ukrainian Academy of Sciences, I. K. Pokhodnya and L. V. Starodubtsev (deceased), engineer, Electric Welding Institute, imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] The effusion cell method is used to study the formation of negative ions upon heating of fluorine-containing slag and certain common welding material components. Poisson's equation is used to analyze the influence of negative ions on the parameters of the arc near the electrode. When large quantities of negative ions are formed upon heating of mixtures of fluorides with rutile and silicone, the electric field intensity in the cathode area of the arc is decreased, significantly if the concentration of negative ions approaches that of positive ions. The electric field intensity in the anode area of the arc and the anode voltage drop increase greatly under the influence of negative ions, resulting in redistribution of voltage in the arc. The negative ion current density upon heating of mixtures of fluorite with rutile and silica to temperatures near the melting point of the fluorite reaches  $10^3$ - $10^4$  A/m<sup>2</sup>, significantly influencing the electric field intensity near the electrodes. References 17: 14 Russian, 3 Western (1 in Russian).

6508/12955  
CSO: 1842/59

## INFLUENCE OF WELDING HEAT CYCLE ON STRUCTURE AND TOUGHNESS OF METAL IN HEAT-AFFECTED ZONE OF HARDENED TYPE 09G2S STEEL

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 29 Oct 85; in final form 27 Jan 86) pp 10-13

[Article by Yu. V. Demchenko, engineer, A. Ye. Asnis, doctor of technical sciences, G. A. Ivashenko and V. G. Vasilev, candidates of technical sciences, and L. K. Doroshenko, engineer, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] Selection of optimal welding conditions and a favorable combination of structure and properties in the heat-affected zone requires information on the transformation of austenite under the conditions of the welding heat cycle. To develop this information for hardened 09G2S steel, the transformation of austenite in hardened and normalized steel of this type was studied under conditions imitating the welding heat cycle with continuous cooling. Hardening was by quenching from 920°C in water with subsequent

tempering at 550°C, (1 hour), using specimens 12 mm thick and yielding a sorbite structure. In the normalized steel the structure was ferrite and pearlite, unevenly distributed. The maximum heating temperature was constant at 1300-1350°C, heating rate in the 800-1000°C interval 150°C/s. Cooling rates were 2.5-75°C/s in the 500-800°C interval, speeds characteristic for heat-affected zone metals in joints welded under flux in carbon dioxide gas. It was found that at cooling rates of 5°C/s or more softening did not occur, assuring a favorable ferrite-beinite structure in the heat-affected zone and guaranteeing an impact toughness of at least 30J/cm<sup>2</sup> at -70°C. Hardening of 09G2S steel favors uniform distribution of austenite conversion products in the heat-affected zone of welded joints. References 7: 5 Russian, 2 Western.

6508/12955  
CSO: 1842/59

UDC [621.791.052:669.15-194.2]:669.788:620.192.46

#### INFLUENCE OF HYDROGEN ON CRACK FORMATION TENDENCY IN HEAT-AFFECTED ZONE WITH STRESS CONCENTRATOR

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 21 Nov 85) pp 20-23

[Article by Corresponding Member, Ukrainian Academy of Sciences, B. S. Kasatkin, O. D. Smiyan, Candidate of Technical Sciences, V. Ye. Mikhaylov, Engineer, V. V. Volkov, Candidate of Technical Sciences, Ye. I. Butkova and V. V. Makarov, Engineers, Electric Welding Institute imeni Ye. O. Paton, Ukrainian Academy of Sciences]

[Abstract] A study is made of the influence of plastic deformation in the area of a stress concentrator on the distribution of hydrogen in a welded joint. Specimens of type 14Kh2GMR steel in the form of 40x7x2 mm plates were notched 0.5 mm deep on one edge, radius of curvature of the notch end being 0.1 mm and notch angle 40°. The specimens were heated by electric current to a maximum temperature of 1350°C; the cooling rate was 30°C/s between 600 and 500°C. The specimens were then ground to remove scale and electrolytically hydrogenated for 30 minutes in 5% H<sub>2</sub>SO<sub>4</sub> containing 1 g/l hyposolufide, then placed in liquid nitrogen to retain the hydrogen. A stream of argon was used to prevent oxidation of the surface during heating and to regulate the cooling pseed. Specimens were removed from liquid nitrogen and placed in alcohol, warmed to room temperature and placed in a bend testing machine. A pulsed laser beam was used to melt the material in the notch zone and remove gaseous impurities, which were recorded by a mass spectrometer. Identical measurements were also performed on specimens not subjected to preliminary hydrogen absorption. Simultaneous hydrogen absorption and loading of the specimens resulted in delayed failure. The stress concentrators caused nonuniform distribution of hydrogen in the steel. The maximum hydrogen concentration was found in advance of the leading edge

of local plastic deformation, well in advance of the developing crack. The logarithm of incubation period length varied linearly as a function of hydrogen concentration in advance of the tip of the notch. References 8: 7 Russian, 1 Western.

6508/12955  
CSO: 1842/59

UDC 621.791.4.052.011:539.378.3:669.295

# SPECIFICS IN INTERACTION OF CONTACT SURFACES UPON DIFFUSION WELDING OF TITANIUM ALLOYS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 22 Aug 85) pp 53-55

[Article by M. B. Nikgolov, engineer, Voronezh]

[Abstract] During diffusion welding of titanium, mechanical and thermal mechanisms both come into play. Selection of an optimal technology requires that the effectiveness of at least one of these two mechanisms be known. To this end, experiments were performed on OT4 and OT4-1 alloys with initial fine-grain globular structure. Circular seams were welded in a chamber with a controlled atmosphere to prevent oxidation. The mechanism involved: full physical contact for one hour at 65°C at specific pressure of 60 MPa; reduction of pressure to 0.2-0.4 MPa; increasing temperature to the welding point and holding for a variable time. Notched specimens were then tested in impact bending. It was found that the energy of thermal fluctuations is insufficient for direct breaking of the bounds of surface atoms. Therefore, their transition to the active state occurs due to the migration of vacancies located on grain boundaries. Considering that the activation energy remains practically constant over time, interaction of the contacting surfaces is possible only upon migration of grain boundaries in the surface layer of the materials contacted due to recrystallization processes. This indicates that technological welding plans involving physical contact primarily in the low temperature area are ineffective. Plans in which pressure is applied after a certain temperature is reached in the joint or a low constant pressure is applied to the welded elements as they are heated are superior. References 6: all Russian.

6508/12955  
CSO: 1842/59

## MHD WAVE GENERATORS FOR AUTOMATED GROUP SOLDERING OF PRINTED CIRCUIT BOARDS

Kiev AVTOMATICHESKAYA SVARKA in Russian No 11, Nov 86 (manuscript received 18 Sep 85) pp 60-62

[Article by Ya. A. Simsons, engineer and Yu. M. Gelfgat, doctor of physical-mathematical sciences, Riga]

[Abstract] The Physics Institute of the Latvian Academy of Sciences and industry have developed and put into production MHD wave generators with helical flow path and an inductor creating a rotating electromagnetic field which produce waves and jets of liquid solder up to 500 mm wide for use in PC board wave soldering devices. The wave generator allows the use of a standard asynchronous electric motor stator as the rotating electromagnetic field inductor and the use of the electromagnetic field created by the inductor to heat and melt the solder in the active zone of the wave generator while providing the required liquid metal head. Cross-sectional diagrams of three versions of the device are presented. The throughput of the wave generator is controlled both by changing the supply voltage and mechanically by raising and lowering the bath of metal with respect to the inductor. The inductor is cooled with compressed air. Air heated in the inductor is used for drying of the PC boards after they are washed. The devices are in successful use under mass production conditions. References 5: all Russian.

6508/12955

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THE USE OF MICA-CRYSTAL REFRACTORIES IN THE CHLORINATION PROCESS OF  
MAGNESIUM AND TITANIUM PRODUCTION

Moscow TSVETNYYE MATERIALY in Russian No 11, Nov 86, pp 50-54

[Article by G. V. Tsidvintsev, N. M. Zuyev and A. V. Kosinskaya]

[Abstract] Joint studies were done by the Casting Problems Institute of the UkSSR Academy of Sciences and the Ust-Kamenogorsk Titanium and Magnesium Combine to determine whether the chemical, physical, and mechanical properties of mica-crystal refractories (SKMs) would make these materials more suitable than other types of refractories for use in the chlorination production of magnesium and titanium. The SKMs tested were made on a base of potassic and potassic-baric fluorophlogopites. The tests showed that these materials have a desirable combination of properties. The potassic mica-based SKM had a fusion temperature of 950°C, volume density of 2.7 grams/cm<sup>3</sup>, open porosity of 0.2% to 0.3%, compressive strength of 833 to 882x10 Pa, thermal conductivity at 850°C of 2.5 to 3.0 watts/meter·K, a coefficient of linear thermal expansion of 6.1 to 7.2 x 10<sup>-6</sup> K, and a thermal resistance of 350 to 400 heating and quenching cycles. For the barium mica-based SKM, these values were, respectively: 1050°C, 2.85, 0.4 to 0.5, 882 to 980, 2.5 to 3.0, 6.5 to 7.0, and 350 to 400. These materials were also highly resistant to corrosion attack. The oxyfluoride melts used to make SKM castings had good casting properties. Thermal expansion was tested on specimens 4x4x50 mm between 20° and 850°C using a DKV-4A dilatometer. Thermal resistance was tested on specimens 30x30x80 mm with no shrinkage defects. The specimens were heated in an electric muffle furnace and held for 20 minutes between 950° and 1300°C before being quenched for 5 minutes in running water. This process was repeated until cracks appeared. Compressive strength was determined as a function of the effect of structure, phase composition, and crystal size on the strength characteristics. References 14: all Russian.

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INDUSTRIAL TESTING AND INTRODUCTION OF SULFATIZATION PROCESS TECHNOLOGY  
FOR PROCESSING LOW-GRADE TANTALUM-NIOBIUM CONCENTRATES

Moscow TSVETNYYE MATERIALY in Russian No 11, Nov 86, pp 54-56

[Article by A. I. Karpukhin, G. I. Ilyina, V. G. Kharlov, A. I. Usenko  
and Yu. G. Popov]

[Abstract] Sulfatization process technology developed by specialists at the Irkutsk State Scientific Research and Design Institute of the Rare Metals Industry and at a related enterprise underwent industrial testing and was adopted at the enterprise. The tests were carried out on the enterprise's hydrometallurgical equipment, which includes six-chambered plexiglass extractors of the mixing and settling apparatus type. For each test, 3 to 4 tons of intractable concentrates was processed. The unconditioned concentrate consisted of 0.8% to 1.5% Ta and 2.2% to 4.3% Nb; the flotation-separated concentrate of 1.4% Ta and 3.9% Nb, and the gravitation-separated concentrate of 4.0% Ta and 11.5% Nb. The columbite and tantalum concentrate was broken down through sulfatization at 340° to 360°C using a mixture of sulfuric acid and ammonium sulfate in the following proportions:  $H_2SO_4$ :  $(NH_4)_2SO_4$  [(2-3):1]. The thick pulp of tantalum and niobium hydroxides thus obtained was lixiviated in a solution of sulfuric acid (400 to 450 grams/liter) and ammonium bifluoride (200 to 300 grams/liter). The solution was decanted and sent on to have the tantalum and niobium extracted. The solid product was agglomerated into cakes, treated with the lixiviation solution, and sent to a special waste site. Tributylphosphate was used to extract the tantalum and niobium. The tantalum was first extracted from the solution of sulfuric acid and ammonium bisulfide and then reextracted from the organic phase with a solution of ammonium fluoride. Niobium was extracted from the raffinate of the tantalum extraction, and the organic phase thus obtained treated with water to reextract the niobium and with a solution of ammonium fluoride to effect the controlled re-extraction of tantalum and niobium. The tantalum and niobium hydroxides were precipitated through neutralization with an ammonium solution constituted from the reextracts. This process improved the production economy of processing intractable tantalum-niobium concentrates. References 1: Russian.

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USING A MIXTURE OF POTASSIUM BUTYL XANTHATE AND HYDROLIZED POLYACRYLAMIDE  
IN THE FLOTATION SEPARATION OF AURIFEROUS ORES

Moscow SVETNYYE MATERIALY in Russian No 11, Nov 86, pp 90-91

[Article by M. A. Orel, V. M. Chibisov and I. V. Lapatukhin]

[Abstract] Mixtures of potassium butyl xanthate and hydrolized polyacrylamide (GPAA) were tested to determine whether they could make the flotation separation of auriferous ores more efficient. The test ore was a streaky and impregnated auriferous sulfide ore consisting of metasomatic, seritic, and schistic aleuro sandstones and granodiorite-porphyrries with a finely dispersed impregnation of pyrite and arsenical pyrite. The gold, present in a colloidal dispersion, was combined with sulfides and carbonaceous schist (86.1%) and gangue minerals (4.05%). The ore was crushed in four stages to a size of 5 to 0 mm, ground in three stages to obtain a 94% to 96% concentration of 0.074-mm particles, subjected to one primary and two control flotations, with the froth from the second control flotation returned to the first control flotation, and, after two cleanings of the crude concentrate, the rinsed product returned to the primary flotation. The ore dressing equipment had an output of 2.9 tons per 24 hours. The process reagents used were (grams per ton): 2000 of soda turned to the first concentrate, the rinsed product returned to the primary flotation. The ore dressing equipment had an output of 2.9 tons per 24 hours. The process reagents used were (grams per ton): 2000 of soda, 500 of copper sulfate, 500 of sodium sulphide, 310 of butyl xanthate, and 80 of T-80. Flotation of the ore was first done in fresh water using only butyl xanthate as the collector. Ten parts xanthate to one part GPAA were then added, with the GPAA added immediately after the xanthate. The experiment was repeated using recycled water. The use of these substances as collectors resulted in a 2.13% increase in the amount of gold extracted using fresh water, and a 2.96% increase using recycled water. The method also showed applicability to other sulfide ores dressed by flotation separation. References 3: all Russian.

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